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Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site

Draft Revised

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Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site

Rocky Mountain Remediation Services, L.L.C.

Environmental Restoration/Waste Management

Sitewide Actions

September 1996

2

TABLE OF CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

The Groundwater Conceptual Plan provides a basis for cleanup and management of contaminated groundwater at the Rocky Flats Environmental Technology Site (RFETS) consistent with the Rocky Flats Cleanup Agreement (RFCA) Preamble, and the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils*. This plan was originally issued in March 1996, but has been revised to reflect the Final RFCA guidance, and to include additional groundwater plume data.

Addressing groundwater on a sitewide basis allows for effective coordination of groundwater activities, and provides consistency in addressing groundwater contamination. Domestic use of groundwater at RFETS will be prevented through institutional controls, therefore, the goal is to manage or cleanup groundwater to protect surface water quality for all agreed-upon uses. In addition, the Groundwater Conceptual Plan identifies, describes, and ranks the principal groundwater contaminant plumes to provide a planning basis for funding and implementation of groundwater actions.

The lateral extent and spread of contaminants in RFETS groundwater is limited by hydrogeologic conditions, therefore, the contaminant plumes are relatively stable. In addition, groundwater discharges to surface water before leaving RFETS and there is a natural vertical barrier to downward migration of contaminated groundwater. Low-permeability claystones form a barrier at least 500-feet thick between contaminated groundwater at RFETS and the Laramie/Fox Hills aquifer.

The volatile organic compound (VOC) contaminant plumes in groundwater have the most potential to impact surface water, and are the primary focus of the Groundwater Conceptual Plan. Contaminant plumes with other, inorganic, constituents are addressed in this plan where surface water is impacted above action levels. The plumes are defined based on the RFCA two-tiered groundwater action levels which are protective of surface water uses as well as protective of the ecological resources.

The groundwater Tier I action levels are used to identify highly contaminated areas as potential cleanup targets and are defined as 100 x Federal Drinking Water Maximum Contaminant Level

4

(MCL) for VOCs. Tier II action levels are used to identify contaminated groundwater that may impact surface water and are defined as the MCL for individual constituents.

The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed that do not exceed the Tier I action levels, but may have the potential to impact surface water, include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard.

Proposed cleanup actions consist of source removal or containment, with capture and treatment or management of the contaminated groundwater. Using available information, potential actions were conceptually developed for each major groundwater contaminant plume. Based on capture and treatment effectiveness, installation and operating costs, and plant infrastructure requirements, passive captive and treatment methods were the preferred conceptual actions. Before each cleanup action can begin, analyses must be done to select the specific cleanup alternative, and to perform engineering design. Additional data may be needed to select the appropriate treatment systems and ensure the proper placement of cleanup systems.

The groundwater contaminant plumes were ranked based on the methodology previously developed to provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

1.0 INTRODUCTION

The Groundwater Conceptual Plan was originally developed as a joint effort between the Department of Energy, Rocky Flats Field Office (DOE/RFFO), Kaiser-Hill Company, L.L.C. (K-H), Rocky Mountain Remediation Services, L.L.C. (RMRS), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). This plan incorporates the final Rocky Flats Cleanup Agreement (RFCA) (July 19, 1996), and guidance from the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils Working Group ("the Working Group"). This Working Group was formed to:

- Provide a basis for future decision making,
- Define the common expectations of all parties, and
- Incorporate land- and water-use controls into site cleanup.

The Groundwater Conceptual Plan was originally issued in March 1996, and has been revised to incorporate changes in RFCA, and additional information on plumes.

1.1 ROCKY FLATS CLEANUP AGREEMENT AND ACCELERATED SITE ACTION PROJECT (ASAP)

RFCA is an agreement between DOE/RFFO, EPA, and CDPHE to ensure the effective and efficient cleanup of RFETS. The RFCA Preamble mandates that environmental cleanup will be implemented through an integrated and streamlined regulatory approach. The RFCA preamble also defines the approximate areal extent of the five future conceptual land uses: (1) capped areas underlain by waste disposal cells or contaminated materials closed in-place, (2) an industrial-use area, (3) restricted open space, (4) restricted open space because of low levels of plutonium contamination in surface soils, and (5) unrestricted open space.

The RFCA Preamble states that the goal of soil and groundwater management and cleanup is the protection of surface water quality for the designated uses. Proposed actions will be designed to

protect ecological resources and to protect the proposed appropriate industrial or open space uses. Groundwater will not be used for any purposes at RFETS, except as related to cleanup activities. ASAP was developed as an accelerated strategy to reduce risks and close RFETS. The ASAP strategy was used to develop the Integrated Site Baseline (ISB), and the Ten Year Plan, a comprehensive action plan to implement the objectives stated in the RFCA Preamble, and to ensure that, after cleanup, surface water and groundwater leaving the site will be acceptable for any use.

The Groundwater Conceptual Plan is based on the ASAP strategy, and incorporates the RFCA Preamble objectives and the *Action Levels and Standards Framework for the Surface Water, Ground Water, and Soils.* This plan provides a basis for cleanup and management of contaminated groundwater at RFETS to protect surface water quality and ecological resources, and is the basis for the groundwater cleanup in the ISB.

1.2 PURPOSE OF THE GROUNDWATER CONCEPTUAL PLAN AT RFETS

Groundwater at RFETS is present in the shallow, unconsolidated sediments and subcropping bedrock throughout the site. In the past, each Operable Unit (OU) investigated groundwater within its boundaries without addressing influences from upgradient sources. However, groundwater is not limited by OU or Individual Hazardous Substance Site (IHSS) boundaries. Several sources may contribute to a single groundwater plume, and groundwater plumes may cross several OUs and contribute to surface water contamination a great distance from the source location. Figure 1-1 shows the location of the principal areas discussed in the text.

The Groundwater Conceptual Plan addresses groundwater on a sitewide basis, to allow effective coordination of groundwater activities, and establish a consistent approach to addressing groundwater contamination. While remediation of groundwater contaminant plumes must consider both the source and the associated groundwater plume, groundwater plume remediation can be performed independently of source remediation. Because there is no exposure pathway to humans from contaminated groundwater, the programmatic goals are to protect surface water and the environment, and limit potential contaminant migration (to the extent practicable).

The three specific goals of the Groundwater Conceptual Plan are to:

1) Identify and describe the principal contaminant plumes in groundwater;

2) Rank the contaminant plumes for the purpose of establishing the priority for cleanup actions, in accordance with the method outlined in the "Environmental Restoration Ranking" (RMRS 1995); and

3) Provide an initial planning basis for funding and the related implementation schedule for groundwater cleanup.

To meet these goals, the Groundwater Conceptual Plan proposes cleanup and/or management of contaminated groundwater through source removal, source control, and/or treatment of dissolved-phase plumes. Contaminated seeps are also addressed, as these represent the distal ends of the contaminated groundwater plumes. The Groundwater Conceptual Plan recommends evaluating whether some areas of contaminated groundwater may remain in place, given that the programmatic goals can be met without active intervention.

1.3 DOCUMENT ORGANIZATION

The conceptual plan for groundwater restoration is presented in five sections: (1) Section 1.0 describes the goals and purpose of the groundwater strategy, and presents the organization of the report; (2) Section 2.0 provides a summary background on groundwater at RFETS; (3) Section 3.0 presents the action levels and standards developed by the Working Group and describes the groundwater monitoring requirements; (4) Section 4.0 describes the various groundwater contaminant plumes present at RFETS and provides an overview of the proposed cleanup actions that may be used; and (5) Section 5.0 summarizes the proposed next steps.

This document also contains two appendices: (1) Appendix A is a list of acronyms used in this text, and (2) Appendix B contains the executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential (RMRS 1996a)

Insert Figure 1-1 here

2.0 HYDROGEOLOGY AT RFETS

A basic understanding of the hydrogeologic setting is important for evaluating the nature and distribution of contaminated groundwater at RFETS. The current reference documents for describing the sitewide geologic, hydrogeologic and groundwater geochemical data at RFETS are the "Geologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995a), the "Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995b), and the "Groundwater Geochemistry Report" (EG&G 1995c). Much of the following discussion was derived from these reports. Unpublished plume maps from the 1995 Well Evaluation Project were modified to generate the plume configuration maps in this report.

The RFETS plant site is located approximately 4 miles east of the Front Range on a nearly flat-lying pediment surface, unconformably overlying nearly flat-lying bedrock (Figure 2-1). A conceptual cross section of the local hydrogeologic setting at RFETS (Figure 2-2) illustrates that at the site, the shallow groundwater flows through two separate water-bearing layers, known as hydrostratigraphic units. These units are defined based on observed differences in hydrologic and geochemical characteristics for each flow system. These units are generally referred to as the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). A third hydrostratigraphic unit, a permeable, deep regional artesian aquifer known as the Laramie-Fox Hills aquifer, lies below the LHSU and is used extensively as a water supply in the greater Denver area. The RFETS hydrostratigraphic units are described in the greater detail in the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (EG&G 1995b).

The UHSU is the predominant water-bearing unit of concern at RFETS and is considered to be equivalent to the "uppermost aquifer" as defined by the Resource Conservation and Recovery Act (RCRA). It consists of unconsolidated, sandy and gravely materials mixed with clay (i.e., alluvium, colluvium, and artificial fill), as well as weathered bedrock claystones and sandstones which are hydraulically connected to the alluvium. The LHSU consists of unweathered claystone with some interbedded siltstones and sandstones. There is a significant difference in the ability of each unit to transmit groundwater. For example, the geometric mean hydraulic conductivity value of 2×10^{-4} centimeters per second (cm/sec) for the Rocky Flats Alluvium (UHSU) is about three orders of magnitude greater than that for unweathered LHSU Laramie claystones (geometric mean of 3×10^{-7}

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Insert Figure 2-2

cm/sec) (EG&G 1995b). The hydraulic conductivities of LHSU materials are similar to that required for a landfill liner. Wells completed in the UHSU and LHSU generally have poor water-yielding characteristics that prevent their development as viable water sources for residential use, although a few isolated UHSU well locations (i.e., bedrock sandstones in OU 2 (EG&G 1992) and valley-fill alluvium in Walnut Creek near Indiana Street (EG&G 1995d) have sustainable well yields that could support limited household use.

The spread of individual groundwater contaminant plumes at RFETS is limited by natural hydrogeologic conditions, including: the magnitude and distribution of hydraulic conductivities and hydraulic gradients; limited aquifer extent and interception of plume fronts by hydrologic boundaries (i.e., interception of groundwater contaminant plumes by drainages); and other physical controls, such as bedrock topography and the presence of discontinuously saturated areas, that constrain and moderate groundwater and contaminant movement.

Generally, groundwater flows slowly at RFETS. For example, using Darcy's Law, the velocity of groundwater moving laterally through the Rocky Flats Alluvium in the East Trenches Area is estimated to be about 50 feet per year (assuming a hydraulic conductivity of 217.3 ft/yr, effective porosity of 0.1, and hydraulic gradient of 0.0213 ft/ft).

Because natural processes such as sorption and geochemical transformation reactions tend to attenuate the movement of organic contaminant plumes in groundwater, the velocity of contaminant movement is expected to be retarded relative to the groundwater flow velocity. Contaminants in the East Trenches Plume are expected to migrate at rates ranging from about 2.5 and 25 feet per year, based on a reasonable range of retardation factors and neglecting the effects of dispersion and diffusion. Other processes may further attenuate contaminant movement, such as diffusion of aqueous contaminants into clayey matrix materials. Therefore, in some cases, plume front movement appears to be imperceptibly slow. The apparent slow migration rate of some contaminant plumes at RFETS, although not fully understood, provides a level of confidence that temporary deferment of remedial actions at these plumes will not result in undue risks to the environment.

Groundwater in the surficial deposits of the UHSU generally flows to the east following bedrock and surface topography, and ultimately discharges to one of three stream drainages which are the main water pathways offsite. These drainages include Walnut and Woman Creeks, which receive groundwater flow from the IA, and Rock Creek, which receives groundwater flow from areas essentially unimpacted by RFETS activities. Surface water flow from the IA is controlled by a series of impoundments in the Walnut and Woman Creek drainages. These impoundments also intercept groundwater flow associated with the valley-fill alluvium and promote intermingling of surface water with groundwater prior to release offsite. As a result, there is no known direct hydraulic connection between impacted groundwater at RFETS and offsite domestic wells.

In partially saturated areas, alluvial UHSU groundwater has been shown to preferentially flow along predepositional channels cut into the underlying bedrock surface (see Figure 2-2). These channels are known to occur in the IA, Solar Ponds, 881 Hillside, 903 Pad, and East Trenches Areas. Groundwater flow is often concentrated within these channels, and hillside contact seeps result where these channels are cut by erosional surfaces. These channels restrict plume spreading and movement. Other hydrogeologic controls for groundwater flow and contaminant transport are hydraulic gradient, distribution of subcropping sandstones and claystones, and topography. In the IA, features such as interceptor drain systems, buried utility lines, and building foundation drains control groundwater flow.

The lithologic and hydraulic characteristics of the LHSU cause it to act as a regional confining layer for the underlying Laramie-Fox Hills aquifer. The LHSU is a natural barrier to vertical groundwater flow and contaminant transport that effectively isolates impacted UHSU groundwater from deeper strata and the Laramie-Fox Hills aquifer (RMRS 1996a). At the IA the LHSU is estimated to measure at least 600 feet in thickness as shown in Figure 2-1 (modified from EG&G 1995a). By comparison, the average RCRA landfill is lined with only a few feet of similar material. These stratigraphic relationships, combined with an observed downward vertical hydraulic gradient, result in a LHSU groundwater flow regime that is effectively separated from the UHSU, and is predominantly vertically downward rather than horizontal. The available data from groundwater monitoring in the LHSU indicates that it is uncontaminated.

The available hydrogeologic and geochemical data suggest that fractures and faults are not significant conduits for downward vertical groundwater flow at RFETS (RMRS 1996a). Evidence of limited shallow hydraulic communication between UHSU and LHSU groundwater was found to exist in some wells, but these occurrences do not present a pattern consistent with known fault locations.

Due to the thickness, lithology, and observed trend of decreasing hydraulic conductivity values with depth for the LHSU, it appears that the LHSU has sufficient hydrologic integrity to provide long term protection of the Laramie-Fox Hills aquifer from shallow groundwater contamination (RMRS 1996a). The executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN is presented in Appendix C and summarizes the hydrologic information used to reach the above conclusions.

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for development of the action levels and standards framework for surface water, ground water, and soils. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and all three media were considered in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (Attachment 5 of RFCA, July 19, 1996) was recently modified to incorporate the clarifications and resolutions of issues that were reached after RFCA was signed. The proposed changes are expected to be completed by October 18, 1996. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources. This framework for groundwater action levels is based on the assumption that contaminated groundwater emerges as surface water before leaving RFETS.

3.2.1 Action Levels

The Working Group has defined the action levels for groundwater Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act. MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated cleanups, and Tier II action levels are protective of surface water quality. This approach is described below.

Tier I

Groundwater Tier I action levels are based on 100 times the MCL (100 x MCL) and were developed to identify potential cleanup targets. Contaminant concentrations in groundwater above the Tier I action levels indicate the presence of groundwater contaminant sources which may pose a risk to surface water quality. If Tier I action levels are exceeded, an evaluation is required to determine if source removal, or other cleanup or management action is necessary to prevent highly contaminated groundwater (i.e., contaminant concentrations exceeding 100 x MCLs) from reaching surface water. (The evaluation process is described in Section 4.1). This report represents the first phase of this evaluation.

Where action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

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* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G in 1995 to establish sitewide cleanup targets for environmental contamination.

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater above MCLs from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of RFCA Attachment 5. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. These wells are located at or near the boundaries of the composite VOC plumes shown in Figure 3-1. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	10692
10194	4087
1986	B206989
1386	

20

Insert Figure 3-1

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan (IMP). The document will combine and replace two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document also will describe recent changes to the groundwater monitoring network.

The IMP will list the wells with their appropriate data quality objectives, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified, until changes proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any required performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water quality through groundwater transport of leached contaminants. As there are too many variables to accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils at RFETS, the Tier I action levels are the same as Tier I action levels for the corresponding contaminants in surface soil. These action levels are human-health risk-based for the appropriate receptor (office work or open-space recreational user), and the approach is conservative since future land use scenarios do not include contact with subsurface soil.

Action levels for VOCs in subsurface soils were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to calculate the expected equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Subsurface soil contaminant levels that would be protective of groundwater to Tier I action levels of 100 x MCLs were then calculated. These action levels for subsurface soils and are provided in Table 4 of RFCA Attachment 5.

Tier I action levels for radionuclides in subsurface soils are the same as Tier I action levels for radionuclides in surface soils, with the total dose from multiple radionuclides calculated by the sum-of-ratios method. These action levels are the more conservative of:

- An annual radiation dose limit of 15 mrem for the appropriate land use receptor, or
- An annual radiation dose limit of 85 mrem for a hypothetical future resident assuming failure of passive control measures.

Additional subsurface soil may need to be remediated or managed to protect surface water quality or ecological resources. These additional sites will be determined on a case-by-case basis.

4.0 GROUNDWATER CONTAMINANT PLUMES AND REMEDIATION

4.1 IDENTIFICATION

The VOC contaminated groundwater plumes at RFETS have the most potential to impact surface water or to migrate offsite as the mobility of VOCs in groundwater far exceeds the mobility of metals and radionuclides. These plumes were defined on the basis of the exceedances of the Tier II action levels and are shown on Figure 3-1. Tier I action levels were compared against all groundwater data to locate areas of highly contaminated groundwater. These areas were plotted and are shown on Figure 4-1 along with proposed locations of the conceptual groundwater actions.

The probable sources of the VOC contaminated groundwater plumes were identified using the available data and process knowledge. The flow diagram (see figure 4-2) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should be targeted for remedial action.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed Tier I action levels. In addition, there are several plumes and areas of interest where contaminant concentrations do not exceed Tier I action levels, or are of very limited extent, but that are of interest due their potential to impact surface water above RFCA action levels, or due to their contaminant concentrations. The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed that do not exceed the Tier I action levels, but may have the potential to impact surface water, include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard.

The 903 Pad and Ryan's Pit Plume, the Mound Plume, and the East Trenches Plume are part of a large composite plume on the east side of RFETS. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

INSERT FIGURE 4-1

INSERT FIGURE 4-2

4.2 DESCRIPTIONS OF CONTAMINATED GROUNDWATER PLUMES

The extent of contaminated groundwater plumes in RFETS groundwater is not rapidly changing (see Section 2.0). The contaminated groundwater plumes are described below with much of the data derived from the relevant RFI/RI reports, data summaries, and the Hydrogeologic Characterization Report (EG&G 1995b).

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as indicated by the fact that hotspots removed in 1994 from this location had elevated plutonium levels (DOE 1995a).

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek (Figure 4.2.1-1). The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

At the 881 Hillside, groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (DOE 1994a).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are typically the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

27

INSERT FIGURE 4-2.1-1

alluvium. The bedrock topography and surficial deposit thickness can be used to extrapolate where groundwater flow may occur (DOE 1994a).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the dry climate and slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3×10^{-3} to 2×10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2×10^{-6} m^2 /sec, approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992 (DOE 1994a).

Groundwater data collected since the installation of the French Drain suggests that the drain is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (DOE 1994a).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location (Figure 4.2.1-1). These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (Figure 4.2.1-1). The eastern source area underlies one of the radiological hot spots

removed in 1994. Both source areas could have been caused by leakage from individual drums (RMRS 1996b).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Figure 4.2.1-1 provides the distribution of contaminant concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996a).

4.2.2 Mound Site Plume

The Mound Site was used for as a disposal site for approximately 1,405 drums from April 1954 to September 1958. Drums contained depleted uranium, beryllium, lathe coolant (about 70% hydraulic oil and 30% carbon tetrachloride) and tetrachloroethene. Plutonium contaminated waste was also stored at this location, but plutonium levels were below detection limits. After it was noted that some of the drums were leaking, the drums were removed along with visibly stained soil. In addition, radioactive soils were removed at later dates.

The OU2 Phase II RFI/RI investigation identified acetone, methylene chloride, tetrachloroethene, trichloroethene and cis-1,3,-dichloropropene in the subsurface soils (DOE 1995b). Characterization results indicate increasing concentrations of tetrachloroethene and trichloroethene to a depth of 20 feet and decreasing concentrations below that depth. The recent Mound investigation (report in preparation) delineated the area of contamination as occurring near borehole 14295 and well 1987, comprising approximately 400 cubic yards.

The Mound Site is located at the northern edge of the pediment where up to 12 feet of Rocky Flats Alluvium overlies fractured claystone of the Arapahoe Formation. The topography slopes steeply to the north away from the Mound Site towards the incised drainage of South Walnut Creek. The Arapahoe No. 1 Sandstone subcrops under the alluvium at the northwest corner of the Mound Site. This sandstone is truncated by the South Walnut Creek drainage and subcrops beneath the colluvium between the Mound Site and South Walnut Creek.

In the vicinity of the Mound Site, the Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses. The hill slope below the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation is covered with unconsolidated colluvium primarily composed of clay, or silty and/or sandy clay. Caliche is common in both alluvium and colluvium. There are numerous slump features are present on the hill slope.

Depth to groundwater is approximately 12 feet at the Mound Site (within the weathered bedrock), and unconsolidated materials are generally dry much of the year. Saturated alluvium occurs in bedrock lows and paleoscours in the top of the bedrock. The groundwater flow appears to be primarily along the bedrock surface and is probably controlled by small channels incised into the bedrock surface. Groundwater flows to the north through the No. 1 Sandstone until it subcrops beneath the colluvium, indicated by a line of seeps along the slope towards South Walnut Creek. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration of precipitation or UHSU groundwater into the underlying unweathered claystone is limited (DOE 1995b).

Recharge occurs primarily through local infiltration of precipitation. The Central Avenue Ditch runs along the southern boundary of the Mound Site and probably also recharges the UHSU groundwater in this area. Discharge from the UHSU is mostly through seeps located where the water bearing units are truncated by the South Walnut Creek, and through evapotranspiration.

The groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound Site (Figure 4-1), to a point of discharge along the south bank of South Walnut Creek, upstream of the RFETS Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound Site area are suspected to be the source of the groundwater contamination. Trench T-1 could possibly contribute to this plume; however, dry wells between the Trench T-1 and the Mound Site indicate that the Mound Site is the primary source of the contaminated groundwater plume. The groundwater plume at the Mound Site apparently receives only minor contribution from VOC contamination at the 903 Pad. Wells in both the No. 1 Sandstone and alluvium upgradient of the Mound Site contain 0 to 2 ug/l total VOCs (DOE 1995b) (Figure 4.2.2-1). There is an east-west bedrock high located between the 903 Pad and Mound Site, near the south side of the Mound Site (Figure 4.2.2-2). VOC contaminated groundwater from the 903 Pad generally flows to the south of the Mound Site, on the south side of this bedrock high.

Thirty-five VOCs were detected in the contaminated groundwater at the Mound Site. All except tetrachloroethene, trichloroethene, cis-1,2-dichloroethene and vinyl chloride were below 100 ug/l. Tetrachloroethene was the predominant contaminant with the highest concentration of 13,000 ug/l found at the Mound Site. The maximum concentrations of cis-1,2-dichloroethene (214 ug/l) and trichloroethene (410 ug/l) were detected with the maximum tetrachloroethene value. Concentrations of these chemicals decrease towards South Walnut Creek. The maximum vinyl chloride concentration detected was 860 ug/l in a well along the South Walnut Creek drainage. The well is located over 500 feet from the source area, which indicates that this is a degradation product, not a primary constituent (DOE 1995b).

The contaminant plume is discharging through surface and subsurface seeps along the hillside, and along seeps on the south bank of South Walnut Creek. At seep SW059, groundwater containing low

INSERT FIGURE 4-2.2-1

INSERT FIGURE 4-2.1-2

levels of VOCs with trace amounts of radionuclides discharges at a rate of 0.5 gallons per minute, or less. The seep water is collected and treated at the Building 891 Combined Water Treatment Facility.

4.2.3 The 903 Pad and Ryan's Pit Plume

This contaminant plume has two closely spaced sources: (1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and (2) Ryan's Pit where VOCs were disposed of in a trench (Figure 4-1). The 903 Pad was characterized as part of the OU 2 Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (DOE 1995b) and the following information was derived from that report.

The 903 Pad area was used to store drums that contained radioactively contaminated oils and volatile organic compounds (VOCs) from the summer of 1958 to January 1967. Approximately three fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered by clean road base and an asphalt cap.

Ryan's Pit, previously referred to as Trench T-2, is located approximately 150 feet south of the 903 Pad (Figure 4.2.2-1). The dimensions of the pit are approximately 20 feet long, 10 feet wide, and five feet deep. The Pit was used as a waste disposal site from 1969 and 1971 for nonradioactive liquid chemical disposal. VOCs disposed at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only the liquids themselves were put in the pit; their containers were either reused or disposed of in other areas.

Materials placed in the Pit were supposedly screened for radionuclide activity prior to disposal. However, field investigations conducted in 1987 through 1993 do not substantiate this claim. The contaminated soils were removed from this site and treated during the 1995 removal action at Ryan's Pit. Free phase tetrachloroethene and motor fuel constituents were found during this removal action, along with degraded drums and plutonium contaminated soils. Free phase DNAPLs are also suspected to exist underneath the 903 Pad as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's solubility).

The 903 Pad is located on the flat surface at the southern edge of the pediment. A south facing hillside slopes downward from the 903 Pad to the SID and Woman Creek. Ryan's Pit is located on the hillside about 200 feet from the southern edge of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The 903 Pad is paved with asphalt, and artificial fill is present under the 903 Pad and covers a large area to the south and east of the Pad.

The Rocky Flats Alluvium is truncated by erosion and does not extend to the Ryan's Pit area. The Ryan's Pit area surficial deposits consist of reworked Rocky Flats Alluvium that has been transported down slope, along with other clay-rich colluvium deposits and fill material. Surficial deposits consist of colluvium between one and eight feet thick which is primarily clay, and silty or sandy clay. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. On the slope, there are numerous slump features, and a large scarp face is located between the 903 Pad and Ryan's Pit.

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at the extreme northwest corner of the 903 Pad. This sandstone is continuous with the Arapahoe No. 1 Sandstone at the Mound Site, where it is truncated by the South Walnut Creek drainage. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thicknesses. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well-defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

A large bedrock low (paleoscour) extends from the 903 Pad east and passes directly south of the Northeast Trenches. This paleoscour is bounded by bedrock highs to the north and south. Near the 903 Pad, there is 20 to 25 feet of relief between the paleoscour and the northern bedrock high, and 5 to 10 feet of relief between the paleoscour and southern bedrock high (see Figure 4.2.2-1). The paleoscour directs groundwater flow to the east till it is truncated by the South Walnut Creek drainage where alluvial groundwater discharges into the head of a well-developed gully. Groundwater flow from the 903 Pad towards the SID and Woman Creek also occurs either by overtopping of the lower, southern bedrock high, or through breaks in the bedrock high. During dry periods, the bedrock highs restrict alluvial groundwater flow to the south and north. During wet periods, when the alluvial groundwater levels are very high, flow may overtop these barriers, primarily to the south.

Groundwater flow in the colluvium follows north-south trending small paleochannels cut into the underlying bedrock claystone. One narrow paleochannel, approximately 150 to 300 feet wide, extends from the 903 Pad south through the Ryan's Pit area (Figure 4.2.2-1). The areas surrounding these paleochannels is unsaturated. The southern extent of groundwater flow is not well defined due to lack of well control.

Recharge is primarily from infiltration of precipitation along with some recharge from ditches and other surface water features. Wells located to the west of the 903 Pad are generally dry as alluvial groundwater inflow from the west is restricted by the claystone bedrock high just west of the 903 Pad. Unconsolidated materials within the medial portion of the paleoscour tend to be saturated, with the extent of saturation greatest during the Spring. Groundwater flow occurs through the No. 1 Sandstone until it subcrops beneath the colluvium. Discharge is primarily to seeps located where the water bearing units are truncated by the South Walnut Creek drainage. All UHSU groundwater is discharged to seeps or into the colluvium.

The 903 Pad and Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from these two source areas. This plume flows southward toward the SID and Woman Creek drainage. The lobe of contaminated groundwater which flows eastward from the 903 Pad is addressed as part of the East Trenches Plume (Figure 4.2.2-1).

Contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the alluvium and colluvium. Total VOC concentrations for the Arapahoe No. 1 Sandstone are approximately 2,500 ug/l adjacent to the west edge of the 903 Pad with concentrations at other locations less than 2 ug/l or non-detects. Fifty-seven VOCs were detected in UHSU groundwater for this plume. However, the primary contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene. The southern component of the contaminant plume derived from the 903 Pad contains total VOCs in the 5,000 ug/l range near the Pad, diminishing to 1,500 to 2,000 ug/l range upgradient of Ryan's Pit. Downgradient of Ryan's Pit, the total VOC concentration in groundwater ranges from 57,000 ug/l near the Pit to 5 ug/l near the distal end of the plume. The total VOC concentration in contaminated groundwater from the 903 Pad which does not also flow through the Ryan's Pit source is also estimated at 5 ug/l when it nears Woman Creek drainage.

The highest concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 ug/l) was detected immediately downgradient of Ryan's Pit and occurred with 1,1-dichloroethene at 380 ug/l. A well installed through the center of the 903 Pad contained concentrations of carbon tetrachloride in groundwater at 20,000 ug/l, chloroform at 39,000 ug/l and methylene chloride at 35,000 ug/l. A well installed though the northeast corner of the Pad detected tetrachloroethene at 14,000 ug/l. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although wells with VOC concentrations exceeding Tier I levels have been observed within the plume away from these sources (Figure 4.2.2-1).

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the South Interceptor Ditch and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit plume will reduce the risk to the environment posed by uncontrolled releases to surface water.

4.2.4 Carbon Tetrachloride Spill Plume

The Carbon Tetrachloride Spill (IHSS 118.1) is located due north of Building 776 and east of Building 730 (Figure 4.2.4-1). While there are other IHSSs that overlap IHSS 118.1, (IHSSs 121-Tank 9, 121-Tank 10, 131, and 144[N]), the contamination in the area is primarily related to the carbon tetrachloride spills.

IHSS 118.1 is the site where an underground, 5,000-gallon, carbon tetrachloride steel storage tank and the associated piping were formerly located. The tank was installed prior to 1970, and probably began leaking shortly after installation. Numerous spills occurred before 1970, some between 100 to 200 gallons (DOE 1992b). The tank ultimately failed in June 1981, releasing carbon tetrachloride into the containment structure. The carbon tetrachloride was pumped from the containment structure to the surrounding ground surface, and the tank was removed along with a limited amount of soil surrounding the tank. The surrounding concrete containment structure was probably removed at this time also, but this has not been verified.

INSERT FIGURE 4-2.4-1

The surrounding area has numerous underground and overhead utilities and structures. These include clay sanitary sewer lines, electrical lines, tunnels between buildings, process waste lines and process waste tanks. Immediately east and partially overlapping this site is a group of four process waste tanks oriented east-west, tank groups T-9 and T-10. T-9 consists of two 22,500 gallon underground concrete storage tanks. T-10 consists of two 4,500 gallon concrete underground tanks. Both sets of tanks were installed in 1955, but are no longer used as process waste tanks. T-9 is currently being utilized as a plenum deluge catch tank for Building 776. No releases from either set has been documented (DOE 1995c).

Due to past construction activities in this area, the material overlying the claystone bedrock is predominantly fill material, probably derived from the Rocky Flats Alluvium, along with some remaining undisturbed Rocky Flats Alluvium. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is estimated at 2.06×10^{-4} cm/sec.

The recent IA investigation found free product in the subsurface soil and groundwater related to IHSS 118.1. All four of the soil borings drilled around T-9 and T-10 intercepted free-phase carbon tetrachloride (DOE 1995c). When a water sample was collected at this location, the liquid separated into two distinct phases. Other VOCs may be present, but the high concentrations of carbon tetrachloride may mask their detection. The top of bedrock surface prior to construction of Building 771 sloped to the northeast. Excavation during construction of this building altered this surface as the claystone surface was found 10 feet or more below where it was expected during the recent field investigations. Excavation may have either increased the slope of the bedrock surface, or created a bedrock low closed by the building. The bedrock in this area is claystone which limits vertical migration of the carbon tetrachloride. As carbon tetrachloride sinks to the lowest possible depth, the bedrock surface, building footing drains, and subsurface structures probably control the extent of the free-product plume and much of the dissolved phase portion of the contaminated groundwater plume.

Groundwater flow in this area is to the northeast towards Buildings 771 and 774 where there are known footing drains (Figure 4.2.4-2). Buildings 701 and 730 are not believed to have subsurface structures. Monitoring wells in the area contain carbon tetrachloride in the groundwater which

INSERT FIGURE 4-2.4-2

indicates that a dissolved plume is present in the groundwater. In addition to carbon tetrachloride, several other VOCs are present in the groundwater plume; primarily 1,1-dichlorethene, chloroform and acetone (Figure 4.2.4-1). This contaminated groundwater plume may eventually reach the North Walnut Creek drainage, especially after removal of the surrounding buildings.

Carbon tetrachloride and trichloroethene concentrations have been detected in a downgradient well completed in the Arapahoe No. 1 Sandstone at the western edge of the Solar Ponds, due east of IHSS 118.1. Carbon tetrachloride concentrations range from approximately 1,000 to 21,000 ug/l and the trichloroethene concentrations range from 2,000 to 8,000 ug/l. The concentrations fluctuate greatly over time, but there is a general decreasing trend. The carbon tetrachloride spill is believed to be the source of this contamination and, if true, this would indicate that there is some eastward movement of the dissolved phase of the plume. The decreasing trend over time may be a result of the VOCs originally in the vadose zone at the time of the spill, flushing out of the upper soil horizon and/or settling to the bedrock surface, where there is less contact with groundwater. It is also possible that the Solar Ponds VOC contaminantion is related to a still unidentified contaminant source.

The Solar Ponds area is in hydraulic connection with subcropping Arapahoe No. 1 Sandstone which could act as a conduit to surface water for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

4.2.5 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area, primarily associated with the trenches on the north side of the East Access Road. These trenches are known as the Northeast Trenches and include Trenches T-3, T-4, T-10 and T-11. Upgradient wells indicate a component of the contaminated groundwater in this area is derived from the VOC contamination in the 903 Pad (see Section 4.2.3 and Figure 4.2.2-1). However, the VOC concentrations in groundwater increase over 100 times after the groundwater passes through Trenches T-3 (IHSS 110) and T-4 (IHSS 111.1), indicating a VOC source is present.

Trench T-3 is located approximately 300 feet north of the East Access Road and immediately west of Trench T-4. Trench T-3 is approximately 134 feet long, 20 feet wide and 10 feet deep (DOE 1992b). Trench T-4 is approximately 110 feet long, 15 feet wide, and 10 feet deep (RMRS 1996c). The trenches were reportedly used sometime between 1954 to 1968 for disposal of sanitary sewage sludge, potentially contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. The trenches are also known to contain DNAPLs, crushed drums, and other miscellaneous waste. Except for the debris found in the trenches, activities of the trench material are below the RFETS soil put-back levels.

Trench T-3 and T-4 are located at the northern edge of the pediment where up to 18 feet of Rocky Flats Alluvium overlies fractured claystone and the No. 1 Sandstone of the Arapahoe Formation. Beyond the pediment boundary, the topography slopes steeply to the north towards South Walnut Creek. Both the alluvium and the Arapahoe No. 1 Sandstone are truncated by the South Walnut Creek drainage. Both of these trenches have been excavated as a source removal action in 1996.

The unconsolidated surficial deposits consist of the Rocky Flats Alluvium and artificial fill in the trenches and are generally dry. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. Thickness of the alluvium is approximately 18 feet at Trench T-4 and 16 feet at Trench T-3. Below the outcrop of the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation, the slope is covered with unconsolidated colluvium primarily composed of clay, or silty and sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Underlying the alluvium to the north of the trenches is the continuation of the claystone bedrock high from the 903 Pad area. The center of the associated paleoscour runs beneath Trenches T-11 and T-10 to the south of Trenches T-3 and T-4 (Figure 4.2.2-2). This feature directs the surficial groundwater flow to the east, away from South Walnut Creek. However, the Arapahoe No. 1 Sandstone subcrops beneath the eastern portion of trench T-3 and most of Trench T-4. This fluvial sandstone is incised into the surrounding bedrock claystone and consists of sandstone, clayey sandstone, and silty sandstone. The channel of the Arapahoe Formation No. 1 Sandstone is approximately 40 feet thick and mostly saturated. Groundwater flow is generally unconfined, and flow within the channel is northward towards South Walnut Creek (EG&G 1995c). The sandstone subcrops beneath the colluvium between the trenches and South Walnut Creek at a spring and seep complex.

The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6 x 10^{-4} cm/sec. The geometric mean for the Arapahoe No. 1 Sandstone hydraulic conductivity is 7 x 10^{-4} cm/sec and the geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Recharge of the Rocky Flats Alluvium is primarily through infiltration of precipitation, and upgradient flow from within the paleoscour. Recharge to the No. 1 Sandstone is from infiltration of precipitation through the surficial deposits, and some flow from upgradient. Discharge is primarily to seeps and springs located where the water bearing units are truncated by South Walnut Creek, and by evapotranspiration.

Contaminated groundwater occurs in the alluvium and in the No. 1 Sandstone that is in hydraulic connection with the alluvium. While 27 VOCs were detected within the UHSU groundwater, the majority were detected at concentrations below 100 ug/l. The major contaminants are trichloroethene (maximum value of 94,000 ug/l), carbon tetrachloride (maximum value of 4,500 ug/l), and tetrachloroethene (maximum value of 1,000 ug/l). During the Soil Vapor Extraction Pilot Test Project, stratified water/NAPL samples were collected and analyzed from Trench T-3. These samples contained high levels of VOCs, up to 37,000,000 ug/l for tetrachloroethene along with semivolatiles, petroleum compounds, and uranium-238 at concentrations up to 3,240 pCi/g (DOE 1995b). In addition, borehole samples collected from T-4 contained 12,000 ug/kg tetrachloroethene and 1,000 ug/kg trichloroethene.

The downgradient boundary of the contaminant plume is located at a spring and seep complex on the south bank of South Walnut Creek, above Ponds B-1 and B-2, where the No. 1 Sandstone subcrops. Concentrations of VOCs above 100 x MCLs have been detected by a recent sampling program conducted at the seep complex. There may be potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut

Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

A lobe of this contaminant plume extends to the east of the East Trenches area along the paleoscour cut into the bedrock surface. However, contaminated groundwater has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored ensure that contaminated groundwater from this lobe does not impact surface water.

4.2.6 IA Plume

Several sources in the IA contribute trichloroethene, tetrachloroethene, and carbon tetrachloride to the contaminated groundwater plume in the IA. The plume is defined based on a small number of wells, and is thought to be principally confined to the east central side of the plant. It is not clear whether it is a large coalesced plume, or discrete areas of contaminated groundwater closely associated with individual source areas. The contaminated groundwater plume is outside of the fenced portion of the protected area (PA) and extends downgradient towards the central portion of the IA. Primary contaminant sources are described below and shown on Figure 4.2.4-1.

IHSSs 117.1 was used as a general storage yard from before 1959 to the early 1970s and is located northeast of Building 551 (DOE, 1992b). The IA soil gas investigations found elevated soil gas levels of tetrachloroethene (2,200 ug/l), with less than 20 ug/l concentrations of trichloroethene and carbon tetrachloride and cis-1,2-dichloroethene. Elevated benzene, toluene, ethylbenzene and xylene (BTEX) levels are present in the southwest edge of the IHSS (OU 13 data summary).

IHSS 117.2, located east of Building 551, was used as a chemical storage site from prior to 1971 until approximately 1988. This site was used to store acids, oils, soaps, solvents, and beryllium scrap metal. Minor leaks and spills occurred (DOE 1992b). The IA soil gas investigations determined the presence of elevated levels of 1,1-dichlorethene (2,700 ug/l) along with concentrations above 100 ug/l for vinyl chloride, cis-1,2 dichloroethene, trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Elevated concentrations of BTEX are also present (DOE 1995d).

There have been numerous carbon tetrachloride spills within Building 776, resulting in suspected under building contamination. This building may be the source of low level concentrations of carbon tetrachloride in groundwater on the eastern side of the plantsite.

The IHSS 157.1 is adjacent to the Building 442 Laundry. Very low level concentrations (below 5 ug/l) of tetrachloroethene (PCE) were detected in soil gas samples from this location (DOE 1995d).

IHSS 158 is an area where waste boxes were staged and loaded onto rail cars. This area is considered a radioactive site, and is located north of Building 551. Soil gas surveys found concentrations above 100 ug/l for vinyl chloride, toluene, and BTEX at this location (DOE 1995d).

IHSS 160 is a parking lot on the west side of Building 444. Drummed and boxed wastes were stored at this location prior to paving, and leaked (HRR). The soil gas survey detected tetrachloroethene at 99 ug/l at this location. Concentrations less than 10 ug/l each of toluene, acetone, and benzene are also present (DOE 1995e).

IHSS 171 is a training area for fire department personnel. In the past, diesel, gasoline and possibly waste solvents were ignited for fire fighting training purposes. The area is currently in use, and a metal tree is used for burning propane for training. Large volumes of water are used during training which may tend to accelerate migration of any contaminant plume. As expected, large concentrations of BTEX are present in the subsurface soils. Soil gas samples do not indicate high concentrations of VOCs. However, during drilling of a geoprobe hole in this IHSS, the rod came up coated with a brown liquid. Unfortunately, a sample could not be collected for analysis. It is possible that free product VOC does exist at this location (DOE 1995d).

The hydrogeology of the IA has not been as extensively studied as other areas at RFETS. The Hydrogeologic Characterization Report (EG&G 1995) was the primary source for the following hydrogeologic information. The IA is located on a pediment capped by the Rocky Flats Alluvium. The pediment has been eroded at the sides to expose the underlying claystone of the Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. Fill material is abundant and usually consists of

reworked Rocky Flats Alluvium. The geometric mean for the hydraulic conductivity all of RFETS Rocky Flats Alluvium is 2.06 x 10^{-4} cm/sec.

Groundwater occurs under unconfined conditions and flow is generally controlled by the topography of the underlying bedrock surface. Groundwater flow direction in the IA is generally eastward, with groundwater in the northern sections flowing to the northeast (Figure 4.2.4-2). Several building footing drain systems locally impact groundwater flow. Small bedrock channels are known to occur which direct the groundwater flow.

The IA groundwater plume is greatly influenced by the RFETS infrastructure. Groundwater recharge in the IA is from upgradient flow, infiltration of precipitation and substantial water losses from sewers and water-supply pipelines. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

The saturated thickness in the IA is typically 5 feet or less, with the greatest saturated thicknesses in the western part of the IA, decreasing to less than 5 feet in the eastern half of the IA. There are many unsaturated zones, particularly in the eastern half of the IA. These unsaturated areas are controlled by the bedrock, with bedrock highs generally dry. The decrease in saturated thickness in the eastern half of the IA may be caused by impermeable areas, such as parking lots and buildings, which greatly limit infiltration. In addition, areas of high local recharge may be created adjacent to the impermeable areas. Approximately 190 of 438 acres within the IA are covered by impermeable material. As a result, a greater amount of storm water runoff is channeled to permeable areas and may account for the large variations in saturated thickness.

Discharge from the IA is probably primarily to building footing drains, engineered structures such as the OU 1 French Drain and the Solar Ponds Interceptor Trench System, and potentially to seeps at the boundary of the IA. Both the Interceptor Trench and OU 1 French Drain have removed sufficient water from the surficial deposits to cause these to be locally unsaturated. Infiltration of groundwater into the underlying bedrock is generally limited due to the low hydraulic conductivity of the unweathered bedrock.

The IA groundwater contaminant plume extent is also controlled by interception of the plume by building footing drains and by the increased permeability and hydraulic conductivity through buried utility corridors. Full understanding of the migration of this plume depends on knowing how the various buildings, utility corridors, and sources interact. Unfortunately, there is insufficient knowledge of these factors to completely determine the configuration of this plume.

Figure 4.2.4-2 shows the average concentrations of VOC contaminants in the groundwater wells, and the probable contaminant sources. Treatment of contaminated groundwater within the IA does not appear to be necessary to protect surface water, because of the limited potential for migration. However, ongoing monitoring and evaluation of the groundwater will continue, to detect any movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand, migrate significantly or become a threat to surface water. Actions such as removal of buildings, removal of subsurface structures, and placing impermeable caps over areas must be examined to determine whether these will increase the movement of the contaminated groundwater plume. Controls may be required if increased groundwater contaminant plume movement results from these actions.

4.2.7 Additional Plumes and Areas of Contaminated Groundwater

There are several areas where there are sporadic occurrences of VOC-contaminated groundwater, or where there are contaminant plumes with VOC concentrations less than 100 x MCLs. Contaminant plumes in the Present Landfill and Solar Ponds groundwater do not contain VOC concentrations greater than 100 x MCLs. However, these plumes are of interest because they are associated with RCRA units. In addition, a widespread but diffuse VOC plume is located near the PU&D Yard west of the Present Landfill. The setting and status of many of these plumes and occurrences are discussed below.

Present Landfill Plume

Operation of the Present Landfill (IHSS 114) for disposal of nonradioactive solid waste began in 1968 and will continue until the new landfill opens, or another method of waste disposal is available. The landfill covers an area of approximately 27 acres (Figure 1-1). The total volume of landfill

material is approximately 415,000 cubic yards and consists of approximately 291,000 cubic yards of waste and 124,000 cubic yards of soil cover.

Elevated tritium and strontium concentrations were detected in leachate draining from the landfill in 1973. To control the migration of contaminants, interim response actions were taken. Interim response activities included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill (West Landfill Pond and East Landfill Pond), a subsurface intercept system for diverting groundwater around the landfill and a subsurface leachate collection system. Between 1977 and 1981, the leachate collection and groundwater intercept system were buried beneath waste during landfill expansion. The lateral expansion of waste placement resulted in waste being located beyond the extent of the subsurface drains to the north and south. In 1982, two soil bentonite slurry walls were constructed to prevent groundwater migration into the expanded landfill area.

Leachate is a product of natural biodegradation, infiltration, precipitation, and migration of groundwater through waste. Approximately 5,756,000 gallons of leachate are present in landfill debris within the intercept system and above the unweathered claystone bedrock which is considered the underlying confining unit. The saturated thickness of surficial materials is greatest near the center of the landfill which suggests that recharge may be occurring by groundwater flow under or through the north groundwater intercept system. Groundwater inflow may be occurring where the groundwater intercept system is not keyed into bedrock. Although an area of the south slurry wall is also not keyed into bedrock, well data indicates that it is effective in diverting groundwater.

During the Phase I RI/RFI investigation, 38 discrete groundwater samples were taken. In addition, 1990-1993 monitoring well data from 52 wells were used as the basis for determination of preliminary contaminants of concern. Groundwater in the UHSU at OU 7 contained metals, radionuclides, organic constituents and nitrates at concentrations higher than background (EG&G 1994).

The highest concentration of chlorinated hydrocarbons occurred in groundwater upgradient of the landfill. VOC contamination upgradient is composed entirely of chlorinated hydrocarbons. In contrast, average BTEX concentrations were highest in leachate collected from within the landfill. The BTEX compounds were not detected in upgradient groundwater. Different types of VOC contamination are presented within the landfill and upgradient (southwest) of the landfill, suggesting that a distinct source of VOC contamination is present upgradient of the landfill.

Two separate groundwater plumes exist in the vicinity of the Present Landfill (Figure 3-1). The plume from the landfill source is located west of the landfill and is migrating down the No Name Gulch drainage. A second plume from an unknown source upgradient of the landfill is located in the groundwater south of the current landfill. The second plume is diverted to the south of the southern slurry wall. A groundwater divide is located approximately 500 feet south of the southern slurry wall.

Antimony, iron, manganese, tritium, uranium-238, chloromethane, ethylbenzene, and vinyl chloride concentrations in the groundwater from the landfill plume exceed the Groundwater Tier II Action Levels. Because of the proximity to No Name Gulch, monitoring and further evaluation are required.

Solar Ponds Nitrate Plume

The Solar Evaporation Ponds (SEPs) consists of five surface water impoundments (Figure 1-1). From 1953 to 1986, these were used to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. The materials placed into the SEPs included radioactively contaminated aluminum scrap metal, alcohol wash solutions, drums of waste radiography solutions, leachate from the Present Landfill, treated sanitary effluent, groundwater intercepted from the Interceptor Trench System (ITS), salt water solutions, wash water from the decontamination of production personnel, cyanide wastes, acid wastes and miscellaneous other compounds (DOE 1995f). Removal of pond sludge began in June 1985 and was completed for all SEPs by January 1995.

The SEPs are on the eastern boundary of the pediment capped by the Rocky Flats Alluvium. Streams have eroded the pediment to the north and south with topographic relief of 50 to 100 feet. Much of the surficial deposits have been disturbed by construction of the SEPs, the ITS, nearby buildings and other infrastructure, however, borehole logs suggest that undisturbed Rocky Flats Alluvium often occurs below the disturbed ground.

Thickness of the unconsolidated material ranges from 0 to 25 feet, and averages about 10 feet. The Rocky Flats Alluvium overlies over the erosional bedrock surface and consist of poorly to moderately sorted gravel, sand, silt and clay with boulder to pebble size clasts derived from the nearby Front Range. Artificial fill was used as for road grade fill, berm construction, recontouring around engineered structures, and to fill in lows for the surface impoundments. Fill consisted of reworked Rocky Flats Alluvium with imported offsite materials including crushed rock, plus sandy clay and gravel with fragments of concrete rubble. The Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and fill materials. Claystone is the predominant subcropping lithology, but the No. 1 Sandstone subcrops in the vicinity of South Walnut Creek.

The shallow, unconfined groundwater occurs in unconsolidated surficial material and fractures in the underlying bedrock and the potentiometric surface generally mimics the surface topography. General flow direction is to the northeast under the SEPs. A bedrock high trending east-west under the SEPs diverts the northern flow to the north-northeast towards North Walnut Creek, and the southern flow to the east-southeast towards South Walnut Creek. Unsaturated areas are present over a large part of the area, in part due to the ITS. However, unsaturated areas to the south and east are not impacted by the ITS. The saturated thickness varies from 0 to 5 feet over most of the area, and is thinner along topographic highs, or on slopes where there are thin alluvium or colluvium deposits. Along North and South Walnut Creek, the saturated interval can be as much as 10 feet thick.

Hydraulic conductivity for the Rocky Flats Alluvium in this area is around 10^{-5} cm/sec. No data were given for the fill material. The hydraulic conductivities for the subcropping bedrock claystone ranges from 10^{-7} to 10^{-9} cm/sec. The hydraulic conductivities for the subcropping bedrock sandstone ranges from 10^{-5} to 10^{-6} cm/sec (DOE 1996b).

A large UHSU nitrate plume extends north and east from the Solar Ponds to the North Walnut Creek drainage above Pond A-1. Three wells with uranium concentrations above background are also found in the contaminated groundwater plume. A lobe of this nitrate plume extends to the southwest for a short distance. While the primary nitrate source has been removed for several years, this contaminant plume still contains nitrates at concentrations above 100 x MCLs. However, samples taken from the ITS show that nitrate concentrations within the plume are decreasing. For November 1993, nitrate concentrations were 366 mg/l, and in June 1995, nitrate concentrations were 277 mg/l (RMRS 1996d). The ITS was installed to intercept contaminants and capture the nitrate plume. It was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gallons of water per year, but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE 1994b).

VOCs are present in the groundwater at the western edge of the Solar Ponds Area and are most likely related to the carbon tetrachloride spill from IHSS 118.1 discussed earlier (Section 4.2.4.) Carbon tetrachloride is present at well P210189 at concentrations of 4,700 ug/l, along with tetrachloroethene at 1981 ug/l and trichloroethene at 2,200 ug/l. This well is completed through 4 feet of silty sandstone at a depth of 31 feet which is believed to be the Arapahoe No. 1 Sandstone. This subcropping sandstone could act as a conduit for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

PU&D Yard Plume

The PU&D Yard has been used since 1974 to store drums, cargo boxes and dumpsters. The PU&D Yard is located northwest of the industrial area in an area approximately 225 feet by 830 feet (Figure 1-1). Materials known to have been stored there include spent batteries, metal shavings coated with lathe coolant, and drums of spent solvents such as paint thinners and waste oils. Drummed hazardous material was also transferred in this area. Subsurface contamination may exist from historical spills associated with past hazardous material transfer operations and storage at the site. Releases of battery acids and leaks from dumpsters and drums of spent solvents and waste oils have been reported.

The PU&D storage yard is underlain by the Rocky Flats alluvium which is approximately 25-30 feet thick in the vicinity. The alluvium is underlain by Arapahoe Formation claystone. Groundwater in this area flows to the east through the UHSU materials, mimicking the surface topography.

Recent soil gas investigations have verified the presence of volatile organic compounds immediately outside the eastern boundary of the PU&D storage yard. Organics, metals, and radionuclides have also been detected in surface soils (DOE 1995g). However, there are no subsurface samples of the soil and groundwater from this area.

An area of poorly defined, contaminated groundwater, with VOC concentrations slightly above the MCLs, is located downgradient of the PU&D Yard, and upgradient and to the south of the Present Landfill. Further investigation is required to identify the source or determine whether there is potential for impact to surface water quality.

Other 881 Hillside Groundwater Contamination

There are several one-time detects of VOCs in groundwater along the 881 Hillside (Figure 1-1). These do not seem to be related to a source, and may be more related to the problems of detecting very low levels of VOCs. In addition, there are two areas where contaminated groundwater has been identified, but where no action is required. Immediately adjacent to Building 881, there are sporadic detects of low concentrations of chlorinated solvents in groundwater. This suggests that several small point sources may exist in this area that are related to building operations.

The UHSU monitoring wells within the IHSS 119.2 drum storage area are dry or do not detect VOCs. However, there are infrequent detects of VOCs in groundwater sampled from two wells located within the drainage downgradient from IHSS 119.2. The source of these sporadic VOC detections may be the volatile plume derived from the 903 Pad.

In addition to the VOC contamination, the 881 Hillside groundwater contains selenium and vanadium at above background levels. Neither of these elements is a documented RFETS waste, nor requires remedial action to protect surface water.

Old Landfill Groundwater Contamination

The Old Landfill was in operation from 1952 to 1968 and was used to dispose of approximately 2 million cubic feet of miscellaneous RFETS waste (Figure 1-1). Accurate and verifiable records of the material placed into this landfill are not available, but all of the waste material was considered non-hazardous at the time. However, paint, solvents, paint thinners, oil, pesticides, and cleaning agents were placed in the landfill as these were not considered hazardous in 1968. The landfill also received some beryllium, depleted uranium, and used graphite. The Old Landfill does not have a liner, but the underlying unweathered claystone has a permeability of 10^{-5} to 10^{-7} cm/sec. The landfill was closed with a soil cover sometime after 1968 and prior to 1980 (DOE 1996c).

Groundwater occurs in the surficial deposits, primarily in the landfill material and alluvium. Many groundwater samples were collected during the OU5 RFI/RI investigation from wells, hydropunch samples from boreholes, and one-time samples from well points. The groundwater COCs identified for the Old Landfill are barium, manganese and radium, however, these do not correlate well with the waste known to be disposed at this site. Two small areas of VOC contaminated groundwater in are present in the Old Landfill area. One area is associated with a subsurface soil gas anomaly, the other is upgradient of the Old Landfill, probably related to the IA (Section 4.2.6).

The OU5 RFI/RI soil gas investigation (DOE 1996c) located two, small, subsurface soil gas anomalies at the Old Landfill. One area is approximately 50 feet by 50 feet and associated soil gas samples contain trichloroethene and 1,1,1-trichloroethene, and the other is about 64 feet by 64 feet and associated soil gas samples contain tetrachloroethene and trichloroethene. Trichloroethene (maximum concentration of 19 ug/l) is sporadically detected in groundwater at one well associated with the larger anomaly. There are no VOCs in groundwater associated with the other anomaly.

One well upgradient of the Old Landfill (P416789) has had three historical detects of TCE. This well is probably detecting contaminated groundwater from the Industrial Area Plume. Seep samples from a location immediately downgradient of this well also contained trace amounts of VOCs.

Walnut Creek Drainage Groundwater Contamination

Several wells in the area of the OU 6 trenches (IHSSs 166.1, 166.2 and 166.3) have detected low-level VOC and metal groundwater contamination. Neither the subsurface soil samples taken from the OU 6 trench area nor the wells within the nearby Present Landfill contain the same contaminants found in the OU 6 wells which are located outside of the Present Landfill slurry wall. However, wells upgradient of the Present Landfill and outside of the slurry wall exhibit similar contaminants and concentrations (see PU&D Yard plume above) (DOE 1996d and EG&G 1994).

There several theories for the occurrence of these low levels of VOCs and metals (DOE 1996d):

- The trenches (IHSSs 166.1 to 166.3) may be the source of contamination and the field investigation did not detect these sources,
- The Present Landfill is the source, and the southern intercept wall is inadequate,
- Wastes may have been emplaced beyond the southern slurry wall, or
- Contamination is from a source upgradient of the Present Landfill, potentially the PU&D yard.

VOC contaminated groundwater is found upgradient of the Present Landfill (average total VOC concentration of 71 ug/l), as well as south of the slurry wall (31 to 68 ug/l average total chlorinated hydrocarbons). In addition, well data indicates the south slurry wall is effective (EG&G 1994). Therefore, it is most likely that the contamination has migrated from a source upgradient of the Present Landfill.

4.3 CLEANUP ALTERNATIVES

The goal of this Groundwater Conceptual Plan is to manage and/or cleanup groundwater in order to be protective of surface water quality. The proposed cleanup of contaminated groundwater involves source removal or source containment, with treatment or management of the contaminated groundwater plumes, to achieve this goal. Conceptual remedies for each major contaminant plume were developed by assessing the available technologies, and proposing a cost-effective, readily available technology.

Both active and passive remedial actions were initially considered. Active treatment actions such as pump-and-treat methods are well-known and accepted, but typically have high operation and maintenance costs, can have a negative impact on wetlands, may consume groundwater, have limited application in clayey aquifers, and are relatively inefficient for DNAPL source removal. Passive treatment actions include passive collection of groundwater with *ex situ* or *in situ* treatment. These systems may have higher initial capital costs, but have lower operation and maintenance costs, low energy consumption, no water consumption, and reduced equipment requirements. Passive treatment will collect DNAPL contaminated groundwater, but also will not remove the source.

The pump-and-treat methodology is commonly used and accepted. EPA has identified the pump-and-treat methodology as one of the most frequently used methods for groundwater remediation, but recognizes that pump-and-treat methods may require decades of potentially expensive operations to achieve cleanup levels (EPA 1992). A preliminary analysis was performed on the potential effectiveness of pump-and-treat methods at RFETS. The analysis concluded that pump-and-treat methods would not be an effective treatment for most contaminant plumes at RFETS, based on the following:

- Neither the UHSU nor the LHSU are capable of producing significant quantities of water, because both have a relatively large clay content.

- Aquifer tests conducted at RFETS show that, for the most part, aquifer yields are low, ranging from 0.000006 gpm to 12 gpm, with an average of 0.3 gpm (EG&G 1995b).

- Factors limiting water production within the UHSU include relatively thin saturated thicknesses and the presence of broad areas that become unsaturated during the fall and early winter (EG&G 1995b).

- Surficial deposits at RFETS have hydraulic conductivities in the 10^{-3} to 10^{-4} cm/sec range, whereas weathered and unweathered claystone bedrock have hydraulic conductivities in the 10^{-7} cm/sec range. The valley-fill alluvium is the most permeable unit, but no contaminant sources are known to be present in this unit.

- Due to the relatively low permeability of the geologic units at RFETS, cones of depression induced by groundwater removal would typically have very steep gradients, requiring a large number of closely spaced wells to effectively implement pump-and-treat remediation.

- Upgradient extraction of groundwater may adversely impact the present widespread distribution of seeps and springs (EG&G 1995b).

- Most of the contaminant plumes in RFETS groundwater have suspected DNAPL sources which are difficult to remediate by using pump-and-treat or passive methods because:

  - DNAPLs have low dissolution rates in water and are denser than water, and therefore tend to sink to the bottom of the unit.
  - The high clay content tends to adsorb DNAPLs, making these difficult or impossible to remove.
  - Pump-and-treat remediation leaves residual DNAPLs, which will continue to act as a source, further releasing dissolved contaminants to the groundwater system.

It may be possible to implement pump-and-treat methods for groundwater near the East Trenches, where the No. 1 Sandstone is contaminated. However, a large number of closely spaced wells would be required to effectively pump-and-treat groundwater due to the low conductivities and the resulting steep cones of depression. DNAPL contamination could easily remain after treatment. For these reasons, and the associated higher costs for this methodology, the pump-and-treat option was not considered as the proposed remediation treatment in this area.

When properly placed, a passive collection system near the distal ends of plumes will effectively capture the DNAPL-contaminated groundwater, but a contaminated plume would be left upgradient to naturally attenuate (DOE 1995h). The contaminants in the plume will degrade with time, and upgradient water will flush the source material toward the collection system.

All proposed actions discussed below were selected to be effective, inexpensive to install and operate, and require minimal plant infrastructure support. For these and the preceding reasons, passive treatment actions are the preferred proposed remediation.

Passive systems proposed for treatment of contaminant plumes in RFETS groundwater include:

- *In situ* passive collection and treatment system such as a funnel and gate, where contaminated groundwater is funneled into a reactive barrier by selective placement of relatively impermeable barriers. Treated water is released back into the groundwater downgradient of the barrier. Such treatment systems have been used effectively at other sites.

- Collection of contaminated water from springs, seeps, and/or shallow drains, then pumping the collected water to an existing treatment facility (Building 891 Combined Water Treatment Facility), and discharging the treated water to the surface water system.

- Passive collection of contaminated water from springs, seeps, and/or shallow drains, then using gravity to feed the collected water through a nearby, *ex situ* treatment system, which uses granulated activated carbon, reactive iron, or other simple treatment options such as air strippers.

The passive treatments proposed in this plan could use any of these methods and are conceptual in nature. No engineering feasibility analyses were performed and the proposed remedial actions were not evaluated with regard to changing site conditions over time. Before implementation of any remedy, an evaluation will be done to determine the most appropriate, effective, implementable, and cost-effective remedy for each plume of contaminated groundwater. The result of these evaluations will be presented as part of ASAP or in a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA), along with the data used to make the decision. It is possible that, as a result of these evaluations, different remedial actions will be selected for the different contaminant plumes in RFETS groundwater.

Assumptions

The proposed conceptual remedial actions for treatment of contaminated groundwater were developed using the following assumptions:

- RFETS groundwater will not be used for domestic or other consumptive purposes, and there are no pathways for contaminated groundwater to directly impact human receptors.

- Groundwater will be managed or remediated to protect surface water and to minimize potential ecological impacts due to entering the surface water system.

- Source removals or containment of subsurface soil sources will be designed to prevent further migration of groundwater containing contaminant concentrations greater than 100 x MCLs.

- Remediation and plume management will preserve wetlands where possible.

- Proposed actions will be implemented using cost-effective methodologies.

- Based on preliminary analysis, passive groundwater treatment or containment would appear to be the preferred remedial alternative for most contaminant plumes in RFETS groundwater.

- Performance monitoring will be conducted for all remediation systems to verify effectiveness.

- The remediation and management decisions described herein are based on the existing data set for contaminant plumes, as well as on known technologies that are believed to be applicable to treatment of RFETS groundwater.

- For this plan, the proposed actions are assumed to be passive treatment or containment devices. Passive treatment systems will be sited downgradient from the sources and coincident with the Tier I boundary within the plume, or where otherwise practicable and feasible. The actual remedial actions and location of these actions will be decided on a case-by-case basis and detailed in an IM/IRA or Proposed Action Memorandum (PAM) before implementation.

- An abbreviated alternatives analysis for any proposed action will be presented as part of ASAP or as an IM/IRA decision document.

- As per RFCA, contaminant plumes in RFETS groundwater which are stable and do not impact surface water above action levels will not require cleanup.

- All remedial actions will be consistent with the proposed end-state of RFETS.

4.4 POTENTIAL CLEANUP ACTIONS

Using available information, the following potential actions were conceptually developed for each major VOC contaminant plume in groundwater. As contaminated seeps are the most distal ends of these contaminated groundwater plumes, these will be managed through cleanup of groundwater sources, natural attenuation, and/or interception at or upgradient of seep locations in accordance with the action level framework and the ER ranking. Further analysis of alternatives for feasibility, cost effectiveness, and suitability must be performed before initiating any action. Figure 4-1 shows the conceptual location of the groundwater actions.

4.4.1 Potential Action for the 881 Hillside Drum Storage Area Plume

The final remedy proposed for OU 1 is to excavate those soils containing VOC concentrations greater than the Tier-I action levels. The volume of the source area requiring excavation is estimated at between 900 and 1,900 cubic yards of colluvium and weathered bedrock. Excavating the source will also remove much of the contaminated groundwater above Tier I action levels (Sampling and Analysis Report, 1996). After demonstrating that this proposed remedy has been effective, and that the source and much of the resulting contaminated groundwater have been removed, the French Drain and recovery well are expected to be removed from operation.

This remedial action will be protective of surface water quality, and should reduce or eliminate any potential long-term stress to environmental receptors of contaminants that may reach Woman Creek.

4.4.2 Potential Action for the Mound Site Plume

Cleanup of the Mound Site contaminated groundwater plume will consist of excavating the subsurface soil exceeding Tier-I action levels for soil cleanup criteria for VOCs. Contaminated materials in Trench T-1 will also be removed using the same criteria. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches South Walnut Creek. Interception of the contaminant plume will be accomplished by making improvements to the existing seep collection system at SW059. The contaminated water is expected to be treated by a passive system installed along the south bank of South Walnut Creek.

Containment and treatment of the contaminant plume in Mound Site groundwater will result in a reduction of risk to the environment posed by uncontrolled releases of contaminated groundwater to surface water.

4.4.3 Potential Action for the 903 Pad and Ryan's Pit Plume

The proposed action is to remove contaminant sources exceeding the Tier I soil action levels for VOCs in soil from the 903 Pad area. Removal of the subsurface soils in the Ryan's Pit area has already been completed. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches Woman Creek. The contaminated water is expected to be treated by a nearby passive system.

4.4.4 Potential Action for the Carbon Tetrachloride Spill Plume

There are three potential actions identified for this groundwater contaminant plume: (1) source removal by using shallow recovery wells to remove as much of the free-phase carbon tetrachloride as possible, (2) removal of the contaminated soils, adjacent tanks, and associated piping, and/or (3) *in situ* treatment such as steam stripping. At this time, the building infrastructure in the area is containing this plume. Monitoring must continue to ensure that contaminated groundwater does not impact surface water. After removal of the infrastructure, near surface capture of this plume may be required to minimize impacts to surface water. If required, the captured water will be treated at a nearby passive treatment plant. This area may be capped as part of the 10-Year Plan. The impact on groundwater must be determined to see if additional controls are necessary.

4.4.5 Potential Action for the East Trenches Plume

Source remediation for Trenches T-3 and T-4 was completed in 1996 to remove subsurface soils that exceed the applicable RFETS soil cleanup criteria for VOCs. This action removed the contaminant source of this contaminated groundwater plume. The remedial action proposed for the remaining contaminated groundwater plume is to install a near-surface plume capture system near the distal end of the plume, and to use passive technologies to treat the contaminated groundwater.

4.4.6 Potential Action for the IA Plume

This groundwater contaminant plume may not require action because source removal and D&D activities should remove contaminant sources, the source of water in the plume will be reduced over time as capping and/or regrading and revegetation reduces infiltration, and water loss from the RFETS utilities will be eliminated. Monitoring must continue to ensure that contaminated groundwater does not migrate, or create a threat to surface water. An upgradient groundwater barrier is not recommended as preliminary calculations indicate that only 15 percent of the present recharge (precipitation plus groundwater influx) to the IA could be diverted by an upgradient barrier, preventing approximately 4 gallons per minute of groundwater flux from entering the IA.

4.4.7 Potential Actions for Additional Plumes

Present Landfill Plume

An interim remedial action has been installed at this location to collect the contaminated groundwater and leachate flowing from the landfill for treatment. This gravity-driven system consists of cement vaults for collecting the contaminated water. Treatment includes a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents. Contaminated water is treated to comply with established cleanup levels. This treatment should effectively mitigate the potential ecological risk from the contaminants of concern. The treatment system may change or be eliminated once the Present Landfill cap is installed, because groundwater migration may no longer be a concern.

Solar Ponds Nitrate Plume

Proposed remedial actions for the groundwater nitrate plume, if required, will be developed at a later date, based on final cleanup standards and site-specific hydrogeologic conditions. No source removal is planned for nitrate-containing media. However, a cap/cover is being considered, which would reduce the groundwater recharge and the flow through the nitrate-contaminated soils.

Recommendations from the Working Group, if approved by the Water Quality Control Commission (WQCC), will change the stream classification for nitrates from drinking water to agricultural. There is some possibility that this surface water will be used for irrigation. Measures are being implemented which will restrict use of this water for domestic use. If the drinking water classification is lifted, then the nitrate concentrations seen in the surface water as a result of the nitrate plume are acceptable for all of the remaining uses, and could be of benefit for irrigation.

PU&D Yard Plume

A limited field investigation will be completed in 1997 to determine the impact to surface water. This may be followed by a source removal the same year. The limited field investigation will determine whether groundwater remedial action(s) are required to protect surface water.

Other 881 Hillside Groundwater Contamination

No action is required to mitigate this plume as it is not impacting, or expected to impact surface water. Any point sources around the building are expected to be dealt with during building demolition.

Old Landfill Groundwater Contamination

The VOC contaminated groundwater associated with the Old Landfill is limited in extent, closely related to a small source area, and is not a threat to surface water quality. Therefore, this contaminated groundwater does not require any action.

Walnut Creek Drainage Groundwater Contamination

It is most likely that the contamination in this area has migrated from a source upgradient of the Present Landfill, potentially the PU&D Yard (see above). Contaminated groundwater in this area will be addressed as part of the remedy for the upgradient plume.

4.5 PLUME RANKING

Sources or contaminant plume above action levels that are determined to be candidates for remedial actions have been prioritized to determine the sequence in which remediation will occur. To accomplish this task, a methodology was developed by CDPHE, EPA, K-H, and RMRS staff to rank the known environmental risks at RFETS and is outlined in the "Environmental Restoration (ER) Ranking" (RMRS 1995).

The ER ranking is currently being updated to incorporate the new action levels. Sites are ranked using the following criteria: 1) concentrations of contaminants present in soil, subsurface soil, and groundwater; 2) impact to surface water; and 3) the potential for further release which quantifies the possibility that source material will continue to release contaminants into the environment. The resulting prioritized list is used to determine the general order in which to implement remedial actions.

This methodology incorporates a very conservative approach. As a result, IHSSs, areas and groundwater plumes where formal risk assessments have determined that there is no unacceptable risk may rank higher than expected on the prioritized list.

The Working Group recommended that the groundwater plumes be prioritized separately from the contaminant sources to allow the groundwater actions to be initiated separately from the source removal actions. The methodology for ranking the groundwater plumes follows:

1) **Action Level Framework Score**: Analytical data for VOCs in groundwater since 1990 were compared to the proposed Tier II action levels, and a ratio of the analytical result to Tier II action level value was calculated. The maximum ratio for each analyte within the

contaminant plume was tabulated, and a total score for each groundwater plume was calculated by summing the maximum ratios. The resulting summed values were then converted to a Score Ratio using Table 4-1.

2) **Impact to Surface Water**: A rating of 1 to 3 was assigned to each plume based on the evaluation of whether or not the groundwater contaminant plume was impacting surface water at Tier I action levels (a rating of 3), had the potential or was impacting surface water at Tier II levels (a rating of 2), or did not pose a threat to surface water at this time (a rating of 1).

3) **Potential for Further Release**: A rating of 1 to 3 is assigned based on an evaluation of whether or not there is a potential for contaminants to continue to migrate into groundwater (i.e., is an uncontained source present?). If there is probably free product present, a rating of 3 is assigned, if high concentrations of contaminant are present in soil, a rating of 2 is assigned and if there is probably no uncontained source present, a rating of 1 is assigned. Because the groundwater plumes are ranked separately from the contaminant sources, and the contaminants are already in the groundwater, the potential for further release for all plumes is rated as a 1.

Table 4-1 Converstion Table for Scores

Summed Groundwater Ratios	*Score Ratio*
> 20,000	10
10,001 - 20,000	9
5,001 - 10,000	8
1,001 - 5,000	7
501 - 1,000	6
251 - 500	5
126 - 250	4
76 - 125	3
26 - 75	2
1 - 25	1

The ER Ranking was recalculated in September 1996 using the new action levels and standards, and including the groundwater contaminant plumes. Table 4-2 provides the rankings of the groundwater contaminant plumes above Tier I action levels as they appear within the overall ER Ranking.

Table 4-2 Ranking of the Groundwater Contaminant Plumes above Tier I Action Levels

Plume	*ER Ranking*	*Comments*
Mound Site	6	
903 Pad and Ryan's Pit	10	Ryan's Pit source removed
East Trenches	11	Trenches T-3 and T-4 sources removed
PU&D Yard	15	
881 Hillside Drum Storage Area	17	
Carbon Tetrachloride Spill	18	
IA	20	
Solar Ponds	22	Ranking due to nitrate concentrations
Present Landfill	26	Groundwater presently collected/treated

5.0 NEXT STEPS

Additional data must be collected and/or analyzed before implementing actions. Not all groundwater contaminant plumes and sources are characterized sufficiently to implement an action, and appropriate methodologies for collection and treatment must be identified. The ecological impacts of groundwater collection and treatment must be determined, as collection of the distal plume boundaries may irreparably damage wetlands and seeps.

Before implementation of any remedy, a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA) or PAM must be prepared, and an engineering design must be completed.

Based on the currently available information, following are the steps already completed towards groundwater remediation, and the proposed next steps. All of these activities have been proposed for funding within the next 5 years.

- Soils in OU 1 881 Hillside Drum Storage Area (IHSS 119.1) that contain contaminant concentrations above action levels may be excavated, removing material above the Tier I Action Level. Because the source of groundwater contamination would be removed, the use of the French Drain system and recovery well may no longer be necessary. After monitoring demonstrates the effectiveness of the remedy, these will be removed from service.

  The seep near Woman Creek will be evaluated to determine whether it is related to the 881 Hillside Drum Storage Area, and if there is an impact to surface water above action levels.

- The source of the Mound plume is anticipated to be remediated as an accelerated action. Pre-remedial investigations were completed in 1996 to delineate the extent of the contaminant source for this plume. Further pre-remedial investigations to determine the extent of the distal end of the groundwater contaminant plume, and effective, passive treatment methodologies are expected to continue in the near future. Gravity-flow passive treatment systems will be the preferred option.

- The sources of the 903 Pad and Ryan's Pit plume are scheduled to be removed. The Ryan's Pit source has already been characterized and remediated. Pre-remedial investigations are proposed to determine the extent of the source. The distal ends of the groundwater contaminant plumes require better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred option.

- A pre-remedial investigation is proposed for the carbon tetrachloride spill plume (IHSS 118.1) to better define the source, and to evaluate remedial actions. After the source is better defined, source removal is recommended. A limited pump and treat system may be installed due to the large amount of free product present in a limited area. If required, after removal of the surrounding buildings and associated footing drain systems, a passive collection and treatment system may be installed to contain the dissolved phase of this plume. This system would be located along the post-building removal, downgradient flow path near the impacted drainage.

- The sources for the East Trenches plume have been removed. Accelerated actions were completed in 1996 to excavate Trenches T-3 and T-4, and materials above the Tier I action levels were removed. The distal end of this groundwater contaminant plume requires better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred options.

- The IA plume will continue to be monitored to ensure that there is no increase in migration, and that there is no impact to surface water quality.

- Groundwater treatment systems need to be investigated to determine the optimum treatment methodology.

- The unknown extent of the chlorinated solvent plumes associated with the PU&D yard (IHSS 170, 174a, and 174b) is a data gap. Because the nature of the southern boundary of these plumes is undetermined, the potential impact to surface water cannot be evaluated. A limited characterization investigation is proposed for 1997 to determine the extent of the plume, and to determine the location, nature and size of the source material. Previous

investigations suggest that the contaminant source(s) may be located immediately east of the known PU&D yard boundary. Source removal is expected to follow in 1997 if a contaminant source can be defined.

- Soil vegetative caps, covers or regrading and revegatation may be used throughout RFETS where necessary to limit natural recharge caused by precipitation from leaching of contaminants in the unsaturated zone and into groundwater: This would aid in reducing the movement of groundwater through the IA, and thereby reduce the mobility of the contaminant plumes. Subsurface sources of groundwater contamination would be removed where practical. At the end of the D&D/remediation phase, the plant water supply and sanitary sewer will be shut off. This will eliminate a major source of groundwater recharge for the IA, and should greatly reduce the mobility contaminant of the IA and carbon tetrachloride spill plumes.

- A limited investigation is proposed for the Solar Ponds area to determine the extent of VOC contamination and whether there is a pathway to surface water. Carbon tetrachloride and trichloroethene are present at a well located near the western side of the SEPs. However, the extent of the contamination in the sandstone, and whether the sandstone subcrops in the North Walnut drainage are unknown.

Further analysis is required to determine optional intercept locations, actual treatment methodologies, and cost-effective project planning and scheduling.

The ER Ranking scheduled to be completed in 1996 and the proposed ranking of groundwater plumes presented in Section 4.5 provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

6.0 REFERENCES

DOE, 1992a, *Final Groundwater Assessment Plan*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, February.

DOE, 1992b, *Final Historical Release Report for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, June.

DOE, 1993, *Final Groundwater Protection and Monitoring Program Plan for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, October.

DOE, 1994a, *Final Phase III RFI/RI Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1*), June 1994.

DOE, 1994b, *RCRA Report.*

DOE, 1995a, *Accelerated Response Action Completion Report, Hot Spot Removal, RFETS, Operable Unit NO.1,* April 1995.

DOE, 1995b, *Final Phase II RFI/RI Report, 903 Pad, Mound, and East Trenches Area, Operable Unit No. 2,* October 1995.

DOE, 1995c, *Draft Data Summary 2, Operable Unit No. 9, Outside Tanks,* October 1995.

DOE, 1995d, *Draft Data Summary 2, Operable Unit No. 13, 100 Area,* June 1995.

DOE, 1995e, *Draft Data Summary 1, Operable Unit No. 14, Radioactive Sites,* June 1995.

DOE, 1995f, *OU 4 Solar Evaporation Ponds, Proposed Interim Measure/Interim Remedial Action, Environmental Assessment Decision Document,* February 1995

DOE 1995g, *Technical Memorandum 1, Operable Unit No. 10, Other Outside Closures,* January 1995.

DOE, 1995h, *Intrinsic Remediation Monitoring Task 1 Evaluation Report,* U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, March 1995.

DOE, 1996a, *Corrective and Remedial Action Proposed Plan, Rocky Flats Environmental Technology Site, Operable Unit 1 - 881 Hillside,* August 1996.

DOE, 1996b, *OU 4 Solar Evaporation Ponds Phase II Ground Water Investigation, Final Field Program Report,* February 1996.

DOE, 1996c, *Final Phase I RFI/RI Report Woman Creek Priority Drainage, Operable Unit 5,* April 1996.

DOE, 1996d, *Final Phase I RFI/RI Report Walnut Creek Priority Drainage, Operable Unit 6,* February 1996.

Driscoll, F. G., 1989, Groundwater and Wells, Third Printing, Johnson Division, St. Paul, Minnesota.

EG&G, 1992, *OU 2 Domestic Water Supply Simulations*, (Internal Report), EG&G Rocky Flats, Golden, Colorado, September, 9p.

EG&G, 1994, Technical Memorandum Final Work Plan OU 7, Volumes 1-4, RF/ER-94-00044, September.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

EG&G, 1995c, *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site*, Volume III of the Sitewide Geosciences Characterization Study, EG&G Rocky Flats, Golden, Colorado, January.

EG&G, 1995d, *1994 Well Evaluation Report for the Rocky Flats Environmental Technology Site (Final),* EG&G Rocky Flats, Golden, Colorado, March.

EPA, 1992, *Chemical Enhancements to Pump-and-Treat Remediation*, U.S. Environmental Protection Agency EPA/540/S-92/001.

EPA, 1994, *Draft Soil Screening Guidance*, U.S. Environmental Protection Agency, EPA/540/R-94/101.

RMRS, 1995, *Environmental Restoration Ranking*, RMRS Rocky Flats, Golden, Colorado, September 27.

RMRS, 1996a, *White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN*, report prepared for Kaiser-Hill Company, August 16, 1996.

RMRS, 1996b, *Sampling and Analysis Report, Identification and Delineation of Contaminant Source Areas for Excavation Design Purposes, IHSS 119.1, OU 1*, April 1996

RMRS, 1996c, *Trenches and Mound Site Characterization Report, RF/ER-96-00044.UN*, September 1996.

RMRS, 1996d, *Management Plan for the Interceptor Trench System Water, RF/ER-96-0031.UN*, July 1996.

ASAP	Accelerated Site Action Plan
CDPHE	Colorado Department of Public Health and Environment
D&D	Decontamination and Decommissioning
DNAPL	Dense Nonaqueous Phase Liquid
DOE/RFFO	Department of Energy/Rocky Flats Field Office
EPA	Environmental Protection Agency
GMAP	Groundwater Monitoring and Assessment Plan
GPMPP	Groundwater Protection and Monitoring Program Plan
GWAP	Groundwater Assessment Plan
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
K-H	Kaiser-Hill
LHSU	Lower Hydrostratigraphic Unit
MCL	Federal Drinking Water Maximum Contaminant Level
OU	Operable Unit
PA	Protected Area
PAM	Proposed Action Memorandum
PPRG	Programmatic Risk-Based Preliminary Remediation Goal
PU&D	Property Utilization and Disposal
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services, L.L.C.
SNM	Special Nuclear Material
TRU	transuranic
UHSU	Upper Hydrostratigraphic Unit
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission

75

Susan Evans' Comments

TABLE OF CONTENTS

76

FIGURES

TABLES

77

EXECUTIVE SUMMARY

The Groundwater Conceptual Plan provides a basis for cleanup and management of contaminated groundwater at the Rocky Flats Environmental Technology Site (RFETS) consistent with the Rocky Flats Cleanup Agreement (RFCA) Preamble, and the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils*. The Groundwater Conceptual Plan describes the management and cleanup of contaminated groundwater at RFETS. This plan was originally issued in March 1996, but has been revised to reflect the Final RFCA, and to include ~~more~~ additional groundwater plume data.

Addressing groundwater on a sitewide basis allows for effective coordination of groundwater activities, and provides consistency in addressing groundwater contamination. ~~Because~~ domestic use of groundwater at RFETS will be prevented through institutional controls, therefore the goal is to manage or cleanup groundwater to protect surface water quality for all agreed-upon uses. In addition, the Groundwater Conceptual Plan identifies, describes, and ranks the principal groundwater contaminant plumes to provide a planning basis for funding and the implementation of groundwater actions.

The lateral extent and spread of contaminants in RFETS groundwater is limited by hydrogeologic conditions, therefore, the contaminant plumes are relatively stable. In addition, groundwater discharges to surface water before leaving RFETS and there is a natural vertical barrier to downward migration of contaminated groundwater. Low-permeability claystones form a barrier at least 500-feet thick between contaminated groundwater at RFETS and the Laramie/Fox Hills aquifer.

this is arguable

The volatile organic compound (VOC) contaminant plumes in groundwater have the most potential to impact surface water, and are the primary focus of the Groundwater Conceptual Plan. ??? Contaminant plumes with other, inorganic, constituents ~~were~~ are addressed in this plan where surface water is impacted above action levels. or will be? A two-tiered approach for action levels was developed for groundwater and soils in order to be protective of both surface water uses ~~as well as to be protective of the~~ and ecological resources. The Tier I action levels were developed to identify highly contaminated areas as potential cleanup targets. For groundwater, these were defined as areas of groundwater contamination where 100 x Federal Drinking Water Maximum Contaminant Level (MCL) for VOCs. Tier II action levels were developed to identify contaminated groundwater that may impact surface water and were defined on the basis of exceedances above the MCL for individual constituents.

Slb ~~concentrations exceed~~

18

Six groundwater contaminant plumes have been identified where contaminant concentrations exceed the Tier I action levels. These contaminant plumes are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Site Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) Industrial Area Plume. In addition, other groundwater plumes do not exceed the Tier I action levels, but may have the potential to impact surface water. These additional plumes include the Present Landfill, Solar Ponds and Property Utilization and Disposal (PU&D) Yard plumes.

Proposed cleanup actions consist of source removal or containment, with capture and treatment or management of the contaminated groundwater. Using available information, potential actions were conceptually developed for each major groundwater contaminant plume. Based on capture and treatment effectiveness, installation and operating costs, and plant infrastructure requirements, passive captive and treatment methods were the preferred conceptual actions. Before each cleanup action can begin, analyses must be done to select the specific cleanup alternative, and to perform engineering design. Additional data may be needed to ensure the proper placement of cleanup systems.

The groundwater contaminant plumes were ranked based on the methodology previously developed to provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

1.0 INTRODUCTION

The Groundwater Conceptual Plan was originally developed as a joint effort between the Department of Energy, Rocky Flats Field Office (DOE/RFFO), Kaiser-Hill Company, L.L.C. (K-H), Rocky Mountain Remediation Services, L.L.C. (RMRS), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). This plan incorporates the final Rocky Flats Cleanup Agreement (RFCA) (July 19, 1996), and guidance from the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils Working Group ("the Working Group"). This Working Group was formed to:

- Provide a basis for future decision making,
- Define the common expectations of all parties, and
- Incorporate land- and water-use controls into site cleanup.

The Groundwater Conceptual Plan was originally issued in March 1996, and has been revised to incorporate changes in RFCA, and additional information on plumes.

1.1 ROCKY FLATS CLEANUP AGREEMENT AND ACCELERATED SITE ACTION PROJECT (ASAP)

The RFCA was finalized between DOE/RFFO, EPA, and CDPHE to ensure the effective and efficient cleanup of RFETS. The RFCA Preamble mandates that environmental cleanup will be implemented through an integrated and streamlined regulatory approach. The RFCA preamble also defines the approximate areal extent of the five future conceptual land uses: (1) capped areas underlain by waste disposal cells or contaminated materials closed in-place, (2) an industrial-use area, (3) restricted open space, (4) restricted open space because of low levels of plutonium contamination in surface soils, and (5) unrestricted open space. RFCA wording

The RFCA Preamble states that the goal of soil and groundwater management and cleanup is the protection of surface water quality for the designated uses. Proposed actions will be designed to

and

protect ecological resources to protect the appropriate industrial or open space uses. Groundwater will not be used for any purposes at RFETS, except as related to cleanup activities.

an accelerated

ASAP was developed as ~~a~~ strategy to reduce risks and close RFETS. The strategy is being used to develop a comprehensive action plan, implement the objectives of the RFCA Preamble and to ensure that, after cleanup, surface water and groundwater leaving the site will be acceptable for any use.

?

or

This Groundwater Conceptual Plan was developed using the ~~conceptual~~ RFCA Preamble objectives and the *Action Levels and Standards Framework for the Surface Water, Ground Water, and Soils.* It ~~conceptually~~ describes the management and cleanup of contaminated groundwater to protect surface water and ecological resources. Conceptual approach to

1.2 PURPOSE OF THE GROUNDWATER CONCEPTUAL PLAN AT RFETS

Groundwater at RFETS is present in the shallow, unconsolidated sediments and subcropping bedrock throughout the site. In the past, each Operable Unit (OU) investigated groundwater within its boundaries without addressing influences from upgradient sources. However, groundwater is not limited by OU or Individual Hazardous Substance Site (IHSS) boundaries. Several sources may contribute to a single groundwater plume, and groundwater plumes may cross several OUs and contribute to surface water contamination a great distance from the source location. Figure 1-1 shows the location of the principal areas discussed in the text.

The Groundwater Conceptual Plan addresses groundwater on a sitewide basis, in order to allow effective coordination of groundwater activities, and establishes a consistent approach to addressing groundwater contamination. While remediation of groundwater contaminant plumes must consider both the source and the associated groundwater plume, groundwater plume remediation can be performed independently of source remediation. Because there is no exposure pathway to humans from contaminated groundwater, the programmatic goals are to protect surface water and the environment, and limit potential contaminant migration (to the extent ~~possible~~).

practicable

The three specific goals of the Groundwater Conceptual Plan are to:

1) Identify and describe the principal contaminant plumes in groundwater;

2) Rank the contaminant plumes for the purpose of establishing the priority for cleanup actions, in accordance with the method outlined in the "Environmental Restoration Ranking" (RMRS 1995); and

3) Provide an initial planning basis for funding and the related implementation schedule of groundwater cleanup.

To meet these goals, the Groundwater Conceptual Plan proposes cleanup and/or management of contaminated groundwater through source removal, source control, and/or treatment of dissolved-phase plumes. Contaminated seeps are also addressed, as these represent the distal ends of the contaminated groundwater plumes. The Groundwater Conceptual Plan also recommends evaluating whether some areas of contaminated groundwater may remain in place, given that the programmatic goals can be met without active intervention.

1.3 DOCUMENT ORGANIZATION

The conceptual plan for groundwater restoration is presented in five sections: (1) Section 1.0 provides an introduction, describes the goals and purpose of the groundwater strategy, and presents the organization of the report; (2) Section 2.0 provides a summary background on groundwater at RFETS; (3) Section 3.0 presents the action levels and standards developed by the Working Group and describes the groundwater monitoring requirements; (4) Section 4.0 describes the various groundwater contaminant plumes present at RFETS and provides an overview of the proposed cleanup actions that may be used; and (5) Section 5.0 summarizes the proposed next steps.

This document also contains three appendices: (1) Appendix A is a list of acronyms used in this text, (2) Appendix B contains Attachment 5 to RFCA, the *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils*, and (3) Appendix C contains the executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company, August 16, 1996

Insert Figure 1-1 here

2.0 HYDROGEOLOGY AT RFETS

A basic understanding of the hydrogeologic setting is important for evaluating the nature and distribution of contaminated groundwater at RFETS. The current reference documents for describing the sitewide geologic, hydrogeologic and groundwater geochemical data at RFETS are the "Geologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995a), the "Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995b), and the "Groundwater Geochemistry Report" (EG&G 1995c). Much of the following discussion was derived from these reports. Unpublished plume maps from the 1995 Well Evaluation Project were modified to generate the plume configuration maps in this report.

regional — disconnect. Jump from regional to local

The HSUs are not shown on fig 2-1 Reference 2-2

Figure 2-1 illustrates the geologic setting of RFETS. Conceptually, the shallow groundwater at RFETS flows through two separate water-bearing layers, known as hydrostratigraphic units. These units are defined based on observed differences in hydrologic and geochemical for each flow system. These units are generally referred to as the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). A third hydrostratigraphic unit, a permeable, deep regional artesian aquifer known as the Laramie-Fox Hills aquifer, lies below the LHSU and is used extensively as a water supply in the RFETS and greater Denver area. The RFETS hydrostratigraphic units are described in the greater detail in the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (EG&G 1995b). Figure 2-2 is a conceptual cross section of the local hydrostratigraphic units at RFETS

The UHSU is the predominant water-bearing unit of concern at RFETS and is considered to be equivalent to the "uppermost aquifer" as defined by the Resource Conservation and Recovery Act (RCRA). It consists of unconsolidated, sandy and gravely materials mixed with clay (i.e., alluvium, colluvium, and artificial fill), as well as weathered bedrock claystones and sandstones which are hydraulically connected to the alluvium. The LHSU consists of unweathered claystone with some interbedded siltstones and sandstones. There is a significant difference in the ability of each unit to transmit groundwater. For example, the geometric mean hydraulic conductivity value of 2×10^{-4} centimeters per second (cm/sec) for the Rocky Flats Alluvium (UHSU) is about three orders of magnitude greater than that for unweathered LHSU Laramie claystones (geometric mean of 3×10^{-7} cm/sec). The hydraulic conductivities of LHSU materials are similar to that required for a landfill liner (EG&G 1995b). Wells completed in the UHSU and LHSU generally have poor water-yielding

84

Insert figure 2-1

characteristics that prevent their development as viable water sources for residential use, although a few isolated UHSU well locations (i.e., bedrock sandstones in OU 2 (EG&G 1992) and valley-fill alluvium in Walnut Creek near Indiana Street (EG&G 1995d) have sustainable well yields that could support limited household use.

The spread of individual groundwater contaminant plumes at RFETS is limited by natural hydrogeologic conditions, including: the magnitude and distribution of hydraulic conductivities and hydraulic gradients; limited aquifer extent and interception of plume fronts by hydrologic boundaries (i.e., interception of groundwater contaminant plumes by drainages); and other physical controls, such as bedrock topography and the presence of discontinuously saturated areas, that constrain and moderate groundwater and contaminant movement.

Groundwater is estimated to flow slowly at RFETS. For example, using Darcy's Law, the velocity of groundwater moving laterally through the Rocky Flats Alluvium in the East Trenches Area is estimated to be about 50 feet per year (assuming a hydraulic conductivity of 217.3 ft/yr, effective porosity of 0.1, and hydraulic gradient of 0.0213 ft/ft).

Because natural processes such as sorption and geochemical transformation reactions tend to attenuate the movement of organic contaminant plumes in groundwater, the velocity of contaminant movement is expected to be retarded relative to the groundwater flow velocity. Contaminants in the East Trenches Plume ~~would then be~~ are expected to migrate at rates ranging from about 2.5 and 25 feet per year, based on a reasonable range of retardation factors and neglecting the effects of dispersion and diffusion. Other processes may further attenuate contaminant movement, such as diffusion of aqueous contaminants into clayey matrix materials. Therefore, in some cases, plume front movement appears to be imperceptibly slow. The apparent slow migration rate of some contaminant plumes at RFETS, although not fully understood, provides a ~~higher~~ level of confidence that temporary deferment of remedial actions at these plumes will not result in undue risks to the environment.

Groundwater in the surficial deposits of the UHSU generally flows to the east following bedrock and surface topography, and ultimately discharges to one of three stream drainages which are the main water pathways offsite. These drainages include Walnut and Woman Creeks, which receive

groundwater flow from the IA, and Rock Creek, which receives groundwater flow from areas essentially unimpacted by RFETS activities. Surface water flow from the IA is controlled by a series of impoundments in the Walnut and Woman Creek drainages. These impoundments also intercept groundwater flow associated with the valley-fill alluvium and promote intermingling of surface water with groundwater prior to release offsite. As a result, here is no known direct hydraulic connection between impacted groundwater at RFETS and offsite domestic wells.

In partially saturated areas, alluvial UHSU groundwater has been shown to preferentially flow along predepositional channels cut into the underlying bedrock surface (see Figure 2-2). These channels are known to occur in the IA, Solar Ponds, 881 Hillside, 903 Pad, and East Trenches Areas. Groundwater flow is often concentrated within these channels, and hillside contact seeps result where these channels are cut by erosional surfaces. These channels restrict plume spreading and movement. Other hydrogeologic controls for groundwater flow and contaminant transport are hydraulic gradient, distribution of subcropping sandstones and claystones, and topography. In the IA, features such as interceptor drain systems, buried utility lines, and building foundation drains control groundwater flow.

after recno the units monitored are effectively separated,

The lithologic and hydraulic characteristics of the LHSU cause it to act as a regional confining layer for the underlying Laramie-Fox Hills aquifer. The LHSU is a natural barrier to vertical groundwater flow and contaminant transport that effectively isolates impacted UHSU groundwater from deeper strata and the Laramie-Fox Hills aquifer (RMRS 1996a). At the IA the LHSU is estimated to measure at least 600 feet in thickness as shown in Figure 2-1 (modified from EG&G 1995a). By comparison, the average RCRA landfill is lined with only a few feet of similar material. These stratigraphic relationships, combined with an observed downward vertical hydraulic gradient, result in a LHSU groundwater flow regime that is predominantly vertically downward rather than horizontal. The available data from groundwater monitoring in the LHSU indicates that it is uncontaminated. ~~with the exception of a few shallow LHSU wells with sporadic and, therefore suspect contaminant occurrences.~~

A strong vertical gradient to flow vertically downward

at RFETS

The available hydrogeologic and geochemical data suggest that fractures and faults are not significant conduits for downward vertical groundwater flow ~~to deep aquifers~~ (RMRS 1996a). Evidence of limited shallow hydraulic communication between UHSU and LHSU groundwater was

87

found to exist in some wells, but these occurrences do not present a pattern consistent with known fault locations. Due to the thickness, lithology, and observed trend of decreasing hydraulic conductivity values with depth for the LHSU, it has been concluded that the LHSU has sufficient hydrologic integrity to provide long term protection of the Laramie/Fox Hills aquifer from shallow groundwater contamination (RMRS 1996). The executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN is presented in Appendix C and summarizes the hydrologic information used to reach the above conclusions.

by who?

by DOE, their subcontractors, and the regulatory agencies

Insert Figure 2-2

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for development of the action levels and standards framework for surface water, ground water, and soils. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and all three media were considered in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (Attachment 5 of RFCA, July 19, 1996) was recently modified to incorporate the clarifications and resolutions of issues that were reached after RFCA was signed. The proposed changes are expected to be completed by October 18, 1996. Appendix B contains these proposed action levels and standards. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.
all ?

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources.

This framework for groundwater action levels is based on the assumption that contaminated groundwater emerges as surface water before leaving RFETS.

3.2.1 Action Levels

The Working Group has defined the action levels for groundwater Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated cleanups, and Tier II action levels are protective of surface water quality. This approach is described below.

Tier I

Groundwater Tier I action levels are based on 100 times the MCL (100 x MCL) and were developed to identify potential cleanup targets. Contaminant concentrations in groundwater above the Tier I action levels indicate the presence of groundwater contaminant sources which may pose a risk to surface water quality. If Tier I action levels are exceeded, an evaluation is required to determine if source removal, or other cleanup or management action is necessary to prevent highly contaminated groundwater (i.e., contaminant concentrations exceeding 100 x MCLs) from reaching surface water. (The evaluation process is described in Section 4.1). This report represents the first phase of this evaluation.

Where action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination. Reference needed

91

resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

Tier II

exceeding MCLs

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of Appendix B. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. These wells are located at or near the boundaries of the composite VOC plumes shown in Figure 3-1, as described in Section 4.2. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	10692
10194	4087
1986	B206989
1386	

92

Insert Figure 3-1

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan (IMP). The document will combine and ~~combine~~ replace ~~incorporate~~ two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document also will describe recent changes to the groundwater monitoring network.

The IMP will list the wells with their appropriate data quality objectives, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, until changes proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis. ~~within the specific decision documents.~~

? If GW [illegible] it doesn't make sense to [illegible]

(We currently don't have any monitoring rqmts included in source removal [PAMs])

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water quality through groundwater transport of leached contaminants. As there are too many variables to accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils at RFETS, the Tier I action levels are the same as Tier I action levels for the corresponding contaminants in surface soil. These action levels are human-health risk-based for the appropriate receptor (office work or open-space recreational user)~~, and are conservative since future land use scenarios do not include contact with subsurface soil.~~ [The levels are not conservative...]

Action levels for VOCs in subsurface soils were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to ~~determine~~ calculate the expected equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Subsurface soil contaminant levels that would be protective of groundwater to Tier I action levels of 100 x MCLs were then calculated. These action levels for subsurface soils and are provided in Table 4 of Appendix B.

Tier I action levels for radionuclides in subsurface soils are the same as ~~applied as~~ Tier I action levels for radionuclides in surface soils, with the total dose from multiple radionuclides calculated by the sum-of-ratios method. These action levels are the more conservative of:

- An annual radiation dose limit of 15 mrem for the appropriate land use receptor, or
- An annual radiation dose limit of 85 mrem for a hypothetical future resident assuming failure of passive control measures.

Additional subsurface soil may need to be remediated or managed to protect surface water quality or ecological resources. These additional sites will be determined on a case-by-case basis.

95

4.0 GROUNDWATER CONTAMINANT PLUMES AND REMEDIATION

4.1 IDENTIFICATION

The VOC contaminated groundwater plumes at RFETS have the most potential to impact surface water or to migrate offsite as the mobility of VOCs in groundwater far exceeds the mobility of metals and radionuclides. These plumes were defined on the basis of the exceedances of the Tier II action levels and are shown on Figure 3-1. Tier I action levels were compared against all groundwater data to locate areas of highly contaminated groundwater. These areas were plotted and are shown on Figure 4-1 along with proposed locations of the conceptual groundwater actions.

The probable sources of the VOC contaminated groundwater plumes were identified using the available data and process knowledge. The flow diagram (see figure 4-2) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should be targeted for remedial action.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed Tier I action levels. In addition, there are several plumes and areas of interest where contaminant concentrations do not exceed Tier I action levels, or are of very limited extent, but that are of interest due their potential to impact surface water above RFCA action levels, or due to their contaminant concentrations. The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed that do not exceed the Tier I action levels, but may have the potential to impact surface water, include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard.

The 903 Pad and Ryan's Pit Plume, the Mound Plume, and the East Trenches Plume are part of a large composite plume on the east side of RFETS. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

96

INSERT FIGURE 4-1

97

INSERT FIGURE 4-2

98

4.2 DESCRIPTIONS OF CONTAMINATED GROUNDWATER PLUMES

The extent of contaminated groundwater plumes in RFETS groundwater is not rapidly changing (see Section 2.0). The contaminated groundwater plumes are described below ~~with much~~ utilizing of the data derived from the relevant RFI/RI reports, data summaries, and the Hydrogeologic Characterization Report (EG&G 1995b).

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as indicated by the fact that the hotspots removed in 1994 (citation of HS removal report?) from this location had elevated plutonium levels.

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek (Figure 4.2.1-1). The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

At the 881 Hillside, ~~Here,~~ groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (DOE 1994a, DOE 1995a).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are typically the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

INSERT FIGURE 4-2.1-1

confusing numbering scheme – but ok I guess

100

alluvium. The bedrock topography and surficial deposit thickness can be used to extrapolate where groundwater flow may occur (DOE 1994a).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the dry climate and slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3×10^{-3} to 2×10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2×10^{-6} m^2/sec, ok approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992. (Citation)

Groundwater data collected since the installation of the French Drain suggests that ~~it~~ the drain is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (DOE 1994a).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location (Figure 4.2.1-1). These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (Figure 4.2.1-1). The eastern source area underlies one of the radiological hot spots

removed in 1994. Both source areas could have been caused by leakage from individual drums (RMRS 1996b).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Figure 4.2.1-1 provides the distribution of contaminant concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996a)..

4.2.2 Mound Site Plume

The Mound Site was used for as a disposal site for approximately 1,405 drums from April 1954 to September 1958. Drums contained depleted uranium, beryllium, lathe coolant (about 70% hydraulic oil and 30% carbon tetrachloride) and tetrachloroethene. Plutonium contaminated waste was also stored at this location, but plutonium levels were below detection limits. After it was noted that some of the drums were leaking, the drums were removed along with visibly stained soil. In addition, radioactive soils were removed at later dates.

? is this real? Unusual contaminant

The OU2 Phase II RFI/RI investigation identified acetone, methylene chloride, tetrachloroethene, trichloroethene and cis-1,3,-dichloropropene in the subsurface soils (DOE 1995b). Characterization results indicate increasing concentrations of tetrachloroethene and trichloroethene to a depth of 20 feet and decreasing concentrations below that depth. The recent Mound investigation delineated the area of contamination as occurring near borehole 14295 and well 1987, comprising approximately 400 cubic yards. ?

citation? in preparation?

The Mound Site is located at the northern edge of the pediment where up to 12 feet of Rocky Flats Alluvium overlies fractured claystone of the Arapahoe Formation. The topography slopes steeply to the north away from the Mound Site towards the incised drainage of South Walnut Creek. The Arapahoe No. 1 Sandstone subcrops under the alluvium at the northwest corner of the Mound Site. This sandstone is truncated by the South Walnut Creek drainage and subcrops beneath the colluvium between the Mound Site and South Walnut Creek.

In the vicinity of the Mound Site, the Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses~~ or beds~~. The hill slope below the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation is covered with unconsolidated colluvium primarily composed of clay, or silty and/or sandy clay. Caliche is common in both alluvium and colluvium. ~~On the slope, there are~~ numerous slump features~~.~~ are present on the slope.

Depth to groundwater is approximately 12 feet at the Mound Site (within the weathered bedrock), and unconsolidated materials are generally dry much of the year. Saturated alluvium occurs in bedrock lows and paleoscours in the top of the bedrock. The groundwater flow appears to be primarily along the bedrock surface and is probably controlled by small channels incised into the bedrock surface. Groundwater flows to the north through the No. 1 Sandstone until it subcrops beneath the colluvium, indicated by a line of seeps along the slope towards South Walnut Creek. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration of precipitation or UHSU groundwater into the underlying unweathered claystone is limited (DOE 1995b).

Ignore this comment → this is the same

Recharge occurs primarily through local infiltration of precipitation. The Central Avenue Ditch runs along the southern boundary of the Mound Site and probably also recharges the UHSU groundwater in this area. Discharge from the UHSU is mostly through seeps located where the water bearing units are truncated by the South Walnut Creek, and through evapotranspiration.

The groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound Site (Figure 4-1), to a point of discharge along the south bank of South Walnut Creek, upstream of the RFETS Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound Site area are suspected to be the source of the groundwater contamination. Trench T-1 could possibly contribute to this plume; however, dry wells between the Trench T-1 and the Mound Site indicate that the Mound Site is the primary source of the contaminated groundwater plume. The groundwater plume at the Mound Site apparently receives only minor contribution from VOC contamination at the 903 Pad. Wells in both the No. 1 Sandstone and alluvium upgradient of the Mound Site contain 0 to 2 ug/l total VOCs (DOE 1995b) (Figure 4.2.2-1). There is an east-west bedrock high located between the 903 Pad and Mound Site, near the south side of the Mound Site (Figure 4.2.2-2). VOC contaminated groundwater from the 903 Pad generally flows to the south of the Mound Site, on the south side of this bedrock high.

Thirty-five VOCs were detected in the contaminated groundwater at the Mound Site. All except tetrachloroethene, trichloroethene, cis-1,2-dichloroethene and vinyl chloride were below 100 ug/l. Tetrachloroethene was the predominant contaminant with the highest concentration of 13,000 ug/l found at the Mound Site. The maximum concentrations of cis-1,2-dichloroethene (214 ug/l) and trichloroethene (410 ug/l) were detected with the maximum tetrachloroethene value. Concentrations of these chemicals decrease towards South Walnut Creek. The maximum vinyl chloride concentration detected was 860 ug/l in a well along the South Walnut Creek drainage. The well is located over 500 feet from the source area; which indicates that this is a degradation product, not a primary constituent (DOE 1995b).

The contaminant plume is discharging through surface and subsurface seeps along the hillside, and along seeps on the south bank of South Walnut Creek. At seep SW059, groundwater containing low

INSERT FIGURE 4-2.2-1

INSERT FIGURE 4-2.1-2

4.2.1-2?

4.2.2-2

waters

levels of VOCs with trace amounts of radionuclides discharges at a rate of 0.5 gallons per minute, or less. The seep is collected and treated at the Building 891 Combined Water Treatment Facility.

4.2.3 The 903 Pad and Ryan's Pit Plume

This contaminant plume has two closely spaced sources: (1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and (2) Ryan's Pit where VOCs were disposed of in a trench (Figure 4-1). The 903 Pad was characterized as part of the OU 2 Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (DOE 1995b) and the following information was derived from that report.

The 903 Pad area was used to store drums that contained radioactively contaminated oils and volatile organic compounds (VOCs) from the summer of 1958 to January 1967. Approximately three fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered by clean road base and an asphalt cap.

Ryan's Pit, previously referred to as Trench T-2, is located approximately 150 feet south of the 903 Pad (Figure 4.2.2-1). The dimensions of the pit are approximately 20 feet long, 10 feet wide, and five feet deep. The Pit was used as a waste disposal site from 1969 and 1971 for nonradioactive liquid chemical disposal. VOCs disposed at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only the liquids themselves were put in the pit; their containers were either reused or disposed of in other areas.

Ryan's Pit also contained degraded drums and plutonium-contaminated soils.

Materials placed in the Pit were supposedly screened for radionuclide activity prior to disposal. However, field investigations conducted in 1987 through 1993 do not substantiate this claim. The contaminated soils were removed from this site and treated during the 1995 removal action at Ryan's Pit. Free phase tetrachloroethene and motor fuel constituents were found during this removal action. Free phase DNAPLs are also suspected to exist underneath the 903 Pad as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's solubility).

The 903 Pad is located on the flat surface at the southern edge of the pediment. A south facing hillside slopes downward from the 903 Pad to the SID and Woman Creek. Ryan's Pit is located on the hillside about 200 feet from the southern edge of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The 903 Pad is paved with asphalt, and ~~there is~~ artificial fill is present under the 903 Pad and covers ~~over~~ a large area to the south and east of the Pad. ~~The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds.~~ redundant w/ earlier

The Rocky Flats Alluvium is truncated by erosion and does not extend to the Ryan's Pit area. The Ryan's Pit area surficial deposits consist of reworked Rocky Flats Alluvium that has been transported down slope, along with other clay-rich colluvium deposits and fill material. Surficial deposits consist of colluvium between one and eight feet thick which is primarily clay, and silty or sandy clay. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. On the slope, there are numerous slump features ~~with~~ and a large scarp face is located between the 903 Pad and Ryan's Pit.

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at the extreme northwest corner of the 903 Pad. This sandstone is continuous with the Arapahoe No. 1 Sandstone at the Mound Site, where it is truncated by the South Walnut Creek drainage. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6 x 10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7 x 10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thicknesses. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well-defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are ~~fairly~~ common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

A large bedrock low (paleoscour) extends from the 903 Pad east and passes directly south of the Northeast Trenches. This paleoscour is bounded by bedrock highs to the north and south. Near the 903 Pad, there is 20 to 25 feet of relief between the paleoscour and the northern bedrock high, and 5 to 10 feet of relief between the paleoscour and southern bedrock high (see Figure 4.2.2-1). The paleoscour directs groundwater flow to the east till it is truncated by the South Walnut Creek drainage where alluvial groundwater discharges into the head of a well-developed gully. Groundwater flow from the 903 Pad towards the SID and Woman Creek also occurs either by overtopping of the lower, southern bedrock high, or through breaks in the bedrock high. During dry periods, the bedrock highs restrict alluvial groundwater flow to the south and north. During wet periods, when the alluvial groundwater levels are very high, flow may overtop these barriers, primarily to the south.

Groundwater flow in the colluvium follows north-south trending small paleochannels cut into the underlying bedrock claystone. One narrow paleochannel, approximately 150 to 300 feet wide, extends from the 903 Pad south through the Ryan's Pit area (Figure 4.2.2-1). The areas surrounding these paleochannels is unsaturated. The southern extent of groundwater flow is not well defined due to lack of well control.

Recharge is primarily from infiltration of precipitation along with some recharge from ditches and other surface water features. Wells located to the west of the 903 Pad are generally dry as alluvial groundwater inflow from the west is restricted by the claystone bedrock high just west of the 903 Pad. Unconsolidated materials within the medial portion of the paleoscour tend to be saturated, with the extent of saturation greatest during the Spring. Groundwater flow occurs through the No. 1 Sandstone until it subcrops beneath the colluvium. Discharge is primarily to seeps located where the water bearing units are truncated by the South Walnut Creek drainage. All UHSU groundwater is discharged to seeps or into the colluvium.

The 903 Pad and Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from these two source areas. This plume flows southward toward the SID and Woman Creek drainage. The lobe of contaminated groundwater which flows eastward from the 903 Pad is addressed as part of the East Trenches Plume (Figure 4.2.2-1).

Contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the alluvium and colluvium. Total VOC concentrations for the Arapahoe No. 1 Sandstone are approximately 2,500 ug/l adjacent to the west edge of the 903 Pad with concentrations at other locations less than 2 ug/l or non-detects. Fifty-seven VOCs were detected in UHSU groundwater for this plume. However, the primary contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene. The southern component of the contaminant plume derived from the 903 Pad contains total VOCs in the 5,000 ug/l range near the Pad, diminishing to 1,500 to 2,000 ug/l range upgradient of Ryan's Pit. Downgradient of Ryan's Pit, the total VOC concentration in groundwater ranges from 57,000 ug/l near the Pit to 5 ug/l near the distal end of the plume. The total VOC concentration in contaminated groundwater from the 903 Pad which does not also flow through the Ryan's Pit source is also estimated at 5 ug/l when it nears Woman Creek drainage.

The highest concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 ug/l) was detected immediately downgradient of Ryan's Pit and occurred with 1,1-dichloroethene at 380 ug/l. A well installed through the center of the 903 Pad contained concentrations of carbon tetrachloride in groundwater at 20,000 ug/l, chloroform at 39,000 ug/l and methylene chloride at 35,000 ug/l. A well installed though the northeast corner of the Pad detected tetrachloroethene at 14,000 ug/l. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although wells with VOC concentrations exceeding Tier I levels have been observed within the plume away from these sources (Figure 4.2.2-1).

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the South Interceptor Ditch and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit plume will reduce the risk to the environment posed by uncontrolled releases to surface water.

4.2.4 Carbon Tetrachloride Spill Plume

The Carbon Tetrachloride Spill (IHSS 118.1) is located due north of Building 776 and east of Building 730 (Figure 4.2.4-1). While there are other IHSSs that overlap IHSS 118.1, (IHSSs 121-Tank 9, 121-Tank 10, 131, and 144[N]), the contamination in the area is primarily related to the carbon tetrachloride spills.

IHSS 118.1 is the site where an underground, 5,000-gallon, carbon tetrachloride steel storage tank and the associated piping were formerly located. The tank was installed prior to 1970, and probably began leaking shortly after installation. Numerous spills occurred before 1970, some between 100 to 200 gallons (DOE 1992b). The tank ultimately failed in June 1981, releasing carbon tetrachloride into the containment structure. The carbon tetrachloride was pumped from the containment structure to the surrounding ground surface, and the tank was removed along with a limited amount of soil surrounding the tank. The surrounding concrete containment structure was probably removed at this time also, but this has not been verified.

The surrounding area has numerous underground and overhead utilities and structures. These include clay sanitary sewer lines, electrical lines, tunnels between buildings, process waste lines and

INSERT FIGURE 4-2.4-1

process waste tanks. Immediately east and partially overlapping this site is a group of four process waste tanks oriented east-west, tank groups T-9 and T-10. T-9 consists of two 22,500 gallon underground concrete storage tanks. T-10 consists of two 4,500 gallon concrete underground tanks. Both sets of tanks were installed in 1955, but are no longer used as process waste tanks. T-9 is currently being utilized as plenum deluge catch tanks for Building 776. No releases from either set has been documented (DOE 1995c).

Due to past construction activities in this area, the material overlying the claystone bedrock is predominantly fill material, probably derived from the Rocky Flats Alluvium, along with some remaining undisturbed Rocky Flats Alluvium. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses ~~of clay silt and sand.~~ The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06 x 10^{-4} cm/sec.

why a diff # than page 4-8?

The recent IA investigation found free product in the subsurface soil and groundwater related to IHSS 118.1. All four of the soil borings drilled around T-9 and T-10 intercepted free-phase carbon tetrachloride (DOE 1995c). When a water sample was collected at this location, the liquid separated into two distinct phases. Other VOCs may be present, but the high concentrations of carbon tetrachloride may mask their detection. The top of bedrock surface prior to construction of Building 771 sloped to the northeast. Excavation during construction of this building altered this surface as the claystone surface was found 10 feet or more below where it was expected during the recent field investigations. Excavation may have either increased the slope of the bedrock surface, or created a bedrock low closed by the building. The bedrock in this area is claystone which limits vertical migration of the carbon tetrachloride. As carbon tetrachloride sinks to the lowest possible depth, the bedrock surface, building footing drains, and subsurface structures probably control the extent of the free-product plume and much of the dissolved phase portion of the contaminated groundwater plume.

Groundwater flow in this area is to the northeast towards Buildings 771 and 774 where there are known footing drains (Figure 4.2.4-2). Buildings 701 and 730 are not believed to have subsurface structures. Monitoring wells in the area contain carbon tetrachloride in the groundwater which indicates that a dissolved plume is present in the groundwater. In addition to carbon tetrachloride, several other VOCs are present in the groundwater plume; primarily 1,1-dichlorethene, chloroform

INSERT FIGURE 4-2.4-2

and acetone (Figure 4.2.4-1). This contaminated groundwater plume may eventually reach the North Walnut Creek drainage, especially after removal of the surrounding buildings.

Carbon tetrachloride and trichloroethene concentrations have been detected in a downgradient well completed in the Arapahoe No. 1 Sandstone at the western edge of the Solar Ponds, due east of IHSS 118.1. Carbon tetrachloride concentrations range from approximately 1,000 to 21,000 ug/l and the trichloroethene concentrations range from 2,000 to 8,000 ug/l. The concentrations fluctuate greatly over time, but there is a general decreasing trend. The carbon tetrachloride spill is believed to be the source of this contamination and, if true, this would indicate that there is some eastward movement of the dissolved phase of the plume. The decreasing trend over time may be a result of the VOCs originally in the vadose zone at the time of the spill, flushing out of the upper soil horizon and/or settling to the bedrock surface, where there is less contact with groundwater. It is also possible that the Solar Ponds VOC contaminantion is related to a still unidentified contaminant source.

to where?

The Solar Ponds area is in hydraulic connection with subcropping Arapahoe No. 1 Sandstone which could act as a conduit for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

4.2.5 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area, primarily associated with the trenches on the north side of the East Access Road. These trenches are known as the Northeast Trenches and include Trenches T-3, T-4, T-10 and T-11. Upgradient wells indicate a component of the contaminated groundwater in this area is derived from the VOC contamination in the 903 Pad (see Section 4.2.3 and Figure 4.2.2-1). However, the VOC concentrations in groundwater increase over 100 times after the groundwater passes through Trenches T-3 (IHSS 110) and T-4 (IHSS 111.1), indicating a VOC source is present.

Trench T-3 is located approximately 300 feet north of the East Access Road and immediately west of Trench T-4. Trench T-3 is approximately 134 feet long, 20 feet wide and 10 feet deep (DOE 1992b). Trench T-4 is approximately 110 feet long, 15 feet wide, and 10 feet deep (RMRS 1996c). The trenches were reportedly used sometime between 1954 to 1968 for disposal of sanitary sewage sludge, potentially contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. The trenches are also known to contain DNAPLs, crushed drums, and other miscellaneous waste. Except for the debris found in the trenches, activities of the trench material are below the RFETS soil put-back levels.

Trench T-3 and T-4 are located at the northern edge of the pediment where up to 18 feet of Rocky Flats Alluvium overlies fractured claystone and the No. 1 Sandstone of the Arapahoe Formation. Beyond the pediment boundary, the topography slopes steeply to the north towards South Walnut Creek. Both the alluvium and the Arapahoe No. 1 Sandstone are truncated by the South Walnut Creek drainage.

In the summer of 1996, T3 and T4 were excavated as a source removal action.

The unconsolidated surficial deposits consist of the Rocky Flats Alluvium and artificial fill in the trenches and are generally dry. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. Thickness of the alluvium is approximately 18 feet at Trench T-4 and 16 feet at Trench T-3. Below the outcrop of the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation, the slope is covered with unconsolidated colluvium primarily composed of clay, or silty and sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Underlying the alluvium to the north of the trenches is the continuation of the claystone bedrock high from the 903 Pad area. The center of the associated paleoscour runs beneath Trenches T-11 and T-10 to the south of Trenches T-3 and T-4 (Figure 4.2.2-2). This feature directs the surficial groundwater flow to the east, away from South Walnut Creek. However, the Arapahoe No. 1 Sandstone subcrops beneath the eastern portion of trench T-3 and most of Trench T-4. This fluvial sandstone is incised into the surrounding bedrock claystone and consists of sandstone, clayey sandstone, and silty sandstone. The channel of the Arapahoe Formation No. 1 Sandstone is approximately 40 feet thick and mostly saturated. Groundwater flow is generally unconfined, and flow within the channel is northward towards South Walnut Creek (EG&G 1995c). The sandstone subcrops beneath the colluvium between the trenches and South Walnut Creek at a spring and seep complex.

department of redundancy department

The geometric mean for the Rocky Flats Alluvium hydraulic conductivity ~~is 6 x 10^{-4}~~ cm/sec. The geometric mean for the Arapahoe No. 1 Sandstone hydraulic conductivity is 7 x 10^{-4} cm/sec and the geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Recharge of the ~~Rocky Flats~~ Alluvium is primarily through infiltration of precipitation, and upgradient flow from within the paleoscour. Recharge to the No. 1 Sandstone is from infiltration of precipitation through the surficial deposits, and some flow from upgradient. Discharge is primarily to seeps and springs located where the water bearing units are truncated by South Walnut Creek, and ~~by evapotranspiration~~.

not clear why we keep repeating this

Contaminated groundwater occurs in the alluvium and in the No. 1 Sandstone that is in hydraulic connection with the alluvium. While 27 VOCs were detected within the UHSU groundwater, the majority were detected at concentrations below 100 ug/l. The major contaminants are trichloroethene (maximum value of 94,000 ug/l), carbon tetrachloride (maximum value of 4,500 ug/l), and tetrachloroethene (maximum value of 1,000 ug/l). During the Soil Vapor Extraction Pilot Test Project, stratified water/NAPL samples were collected and analyzed from Trench T-3. Extremely high levels of VOCs were recorded, up to 37,000,000 ug/l for tetrachloroethene along with semivolatiles, petroleum compounds, and uranium-238 at concentrations up to 3,240 pCi/g (DOE 1995b). from T-3? In addition, during drilling activities, tetrachloroethene and trichloroethene were detected at concentrations of 12,000 and 1,000 ug/kg in Trench T-4.

~~Discuss T-3 – T4 Source removal – refer to previous note~~

The downgradient boundary of the contaminant plume is located at a spring and seep complex on the south bank of South Walnut Creek, above Ponds B-1 and B-2, where the No. 1 Sandstone subcrops. (Figure X-X) Concentrations of VOCs above 100 x MCLs have been detected by a recent sampling program conducted at the seep complex. There ~~are~~ may be potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

117

A lobe of this contaminant plume extends to the east of the East Trenches area along the paleoscour cut into the bedrock surface. However, contaminated groundwater has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored ensure that contaminated groundwater from this lobe does not impact surface water.

I thought it was several discrete areas of cont. gw based on the fact that each has a different "source" combination of contaminants. Weren't ~~the~~ pulled the data together any more than that? (I understand if we haven't had the staff to do this)

4.2.6 IA Plume

Several sources in the IA contribute trichloroethene, tetrachloroethene, and carbon tetrachloride to the contaminated groundwater plume in the IA. The plume is defined based on a small number of wells, and is thought to be principally confined to the east central side of the plant. It is not clear whether it is a large coalesced plume, or discrete areas of contaminated groundwater closely associated with individual source areas. The contaminated groundwater plume is outside of the fenced portion of the protected area (PA) and extends downgradient towards the central portion of the IA. Primary contaminant sources are described below and shown on Figure 4.2.4-1.

IHSSs 117.1 was used as a general storage yard from before 1959 to the early 1970s and is located northeast of Building 551 (DOE, 1992b). The IA field investigations found elevated soil gas levels of tetrachloroethene (2,200 ug/l) during the soil gas survey, with less than 20 ug/l concentrations of trichloroethene and carbon tetrachloride and cis-1,2-dichloroethene. Elevated benzene, toluene, ethylbenzene and xylene (BTEX) levels are present in the southwest edge of the IHSS (OU 13 data summary).

~~in groundwater~~?

do soil gas surveys report in ug/l? or does this from a water sample?

IHSS 117.2, located east of Building 551, was used as a chemical storage site from prior to 1971 until approximately 1988. This site was used to store acids, oils, soaps, solvents, and beryllium scrap metal. Minor leaks and spills occurred (DOE 1992b). The IA field investigations have determined the presence of elevated levels of 1,1-dichlorethene (2,700 ug/l) along with concentrations above 100 ug/l for vinyl chloride, cis-1,2 dichloroethene, trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Elevated concentrations of BTEX are also present (DOE 1995d).

in groundwater ?

Need to clarify throughout the section that the concentrations cited are in soil gas, not groundwater

118

There have been numerous carbon tetrachloride spills within Building 776, resulting in suspected under-building contamination. This building may be the source of low level concentrations of carbon tetrachloride in groundwater on the eastern side of the plantsite.

The IHSS 157.1 is adjacent to the Building 442 Laundry. Very low level concentrations (below 5 ug/l) of tetrachloroethene (PCE) were detected at this location (DOE 1995d).

In soil gas

IHSS 158 is an area where waste boxes were staged and loaded onto rail cars. This area is considered a radioactive site, and is located north of Building 551. Soil gas surveys found concentrations above 100 ug/l for vinyl chloride, toluene, and BTEX at this location (DOE 1995d).

IHSS 160 is a parking lot on the west side of Building 444. Drummed and boxed waste were stored at this location prior to paving, and leaked (HRR). The soil gas survey detected tetrachloroethene at 99 ug/l at this location. Concentrations less than 10 ug/l each of toluene, acetone, and benzene are also present (DOE 1995e).

IHSS 171 is a training area for fire department personnel. In the past, diesel, gasoline and possibly waste solvents were ignited for fire fighting training purposes. The area is currently in use, and a metal tree is used for burning propane for training. Large volumes of water are used during training which may tend to accelerate migration of any contaminant plume. As expected, large concentrations of BTEX are present in the subsurface soils. Soil gas samples do not indicate high concentrations of VOCs. However, during drilling of a geoprobe hole in this IHSS, the rod came up coated with a brown liquid. Unfortunately, a sample could not be collected for analysis. It is possible that free product VOC does exist at this location (DOE 1995d).

The hydrogeology of the IA has not been as extensively studied as other areas at RFETS. The Hydrogeologic Characterization Report (EG&G 1995) was the primary source for the following hydrogeologic information. The IA is located on a pediment capped by the Rocky Flats Alluvium. The pediment has been eroded at the sides to expose the underlying claystone of the Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. Fill material is abundant and usually consists of

reworked Rocky Flats Alluvium. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

on the pediment?

Groundwater occurs under unconfined conditions and flow is generally controlled by the topography of the underlying bedrock surface. Groundwater flow direction in the IA is generally eastward, with groundwater in the northern sections flowing to the northeast (Figure 4.2.4-2). Several building footing drain systems locally impact groundwater flow. Small bedrock channels are known to occur which direct the groundwater flow.

The IA groundwater plume is greatly influenced by the RFETS infrastructure. Groundwater recharge in the IA is from upgradient flow, infiltration of precipitation and substantial water losses from sewers and water-supply pipelines. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

The saturated thickness in the IA is typically 5 feet or less, with the greatest saturated thicknesses in the western part of the IA, decreasing to less than 5 feet in the eastern half of the IA. There are many unsaturated zones, particularly in the eastern half of the IA. These unsaturated areas are controlled by the bedrock, with bedrock highs generally dry. The decrease in saturated thickness in the eastern half of the IA may be caused by impermeable areas, such as parking lots and buildings, which greatly limit infiltration. In addition, areas of high local recharge may be created adjacent to the impermeable areas. Approximately 190 of 438 acres within the IA are covered by impermeable material. As a result, a greater amount of storm water runoff is channeled to permeable areas and may account for the large variations in saturated thickness.

Discharge from the IA is probably primarily to building footing drains, engineered structures such as the OU 1 French Drain and the Solar Ponds Interceptor Trench System, and potentially to seeps at the boundary of the IA. Both the Interceptor Trench and OU 1 French Drain have removed sufficient water from the surficial deposits to cause these to be locally unsaturated. Infiltration of groundwater into the underlying bedrock is generally limited due to the low hydraulic conductivity of the unweathered bedrock.

The IA groundwater contaminant plume extent is also controlled by interception of the plume by building footing drains and by the increased permeability and hydraulic conductivity through buried utility corridors. Full understanding of the migration of this plume depends on knowing how the various buildings, utility corridors, and sources interact. Unfortunately, there is insufficient knowledge of these factors to completely determine the configuration of this plume.

Figure 4.2.4-2 shows the average concentrations of VOC contaminants in the groundwater wells, and the probable contaminant sources. Treatment of contaminated groundwater within the IA does not appear to be necessary to protect surface water, because of the limited potential for migration. However, ongoing monitoring and evaluation of the groundwater will continue, to detect any ~~possible~~ movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand, migrate significantly or become a threat to surface water. Actions such as removal of buildings, removal of subsurface structures, and placing impermeable caps over areas must be examined to determine whether these will increase the movement of the contaminated groundwater plume. Controls may be required if increased groundwater contaminant plume movement results from these actions.

4.2.7 Additional Plumes and Areas of Contaminated Groundwater

There are several areas where there are sporadic occurrences of VOC-contaminated groundwater, or where there are contaminant plumes with VOC concentrations less than 100 x MCLs. Contaminant plumes in the Present Landfill and Solar Ponds groundwater do not contain VOC concentrations greater than 100 x MCLs. However, these plumes are of interest because they are associated with RCRA units. In addition, a widespread but diffuse VOC plume is located near the PU&D Yard west of the Present Landfill. The setting and status of many of these plumes and occurrences are discussed below.

Present Landfill Plume

Operation of the Present Landfill (IHSS 114) for disposal of nonradioactive solid waste began in 1968 and will continue until the new landfill opens, or another method of waste disposal is available. The landfill covers an area of approximately 27 acres (Figure 1-1). The total volume of landfill

material is approximately 415,000 cubic yards and consists of approximately 291,000 cubic yards of waste and 124,000 cubic yards of soil cover.

Elevated tritium and strontium concentrations were detected in leachate draining from the landfill in 1973. To control the migration of contaminants, interim response actions were taken. Interim response activities included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill (West Landfill Pond and East Landfill Pond), a subsurface intercept system for diverting groundwater around the landfill and a subsurface leachate collection system. Between 1977 and 1981, the leachate collection and groundwater intercept system ~~was~~ were buried beneath waste during landfill expansion. The lateral expansion of waste placement resulted in waste being located beyond the extent of the subsurface drains to the north and south. In 1982, two soil bentonite slurry walls were constructed to prevent groundwater migration into the expanded landfill area.

Leachate is a product of natural biodegradation, infiltration, precipitation, and migration of groundwater through waste. Approximately 5,756,000 gallons of leachate are present in landfill debris within the intercept system and above the unweathered claystone bedrock which is considered the underlying confining unit. The saturated thickness of surficial materials is greatest near the center of the landfill which suggests that recharge may be occurring by groundwater flow under or through the north groundwater intercept system. Groundwater inflow may be occurring where the groundwater intercept system is not keyed into bedrock. Although an area of the south slurry wall is also not keyed into bedrock, well data indicates that it is effective in diverting groundwater.

During the Phase I RI/RFI investigation, 38 discrete groundwater samples were taken. In addition, 1990-1993 monitoring well data from 52 wells were used as the basis for determination of preliminary contaminants of concern. Groundwater in the UHSU at OU 7 contained metals, radionuclides, organic constituents and nitrates at concentrations higher than background (EG&G 1994).

The highest concentration of chlorinated hydrocarbons occurred in groundwater upgradient of the landfill. VOC contamination upgradient is composed entirely of chlorinated hydrocarbons. In contrast, average BTEX concentrations were highest in leachate collected from within the landfill. The BTEX compounds were not detected in upgradient groundwater. Different types of VOC contamination are presented within the landfill and upgradient (southwest) of the landfill, suggesting that a distinct source of VOC contamination is present upgradient of the landfill.

plume

of

Two separate groundwater plumes exist in the vicinity of OU ~~7~~. The ~~plume from th~~e landfill source is located west of the landfill and is migrating down the No Name Gulch drainage. A second plume from an unknown source upgradient of the landfill is located in the groundwater south of the current landfill. The second plume is diverted around the southern slurry wall~~, and then possibly migrates to the No Name Gulch drainage and/or Walnut Creek. A~~ groundwater divide is located approximately 500 feet south of the southern slurry wall. Antimony, iron, manganese, tritium, uranium-238, chloromethane, ethylbenzene, and vinyl chloride concentrations in the groundwater exceed the Groundwater Tier II Action Levels. Because of the proximity to No Name Gulch, monitoring and further evaluation ~~is~~ are required.

we don't know that don't speculate

south of the landfill?

Solar Ponds Nitrate Plume

The Solar Evaporation Ponds (SEPs) consists of five surface water impoundments (Figure 1-1). From 1953 to 1986, these were used to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. The materials placed into the SEPs included radioactively contaminated aluminum scrap metal, alcohol wash solutions, drums of waste radiography solutions, leachate from the Present Landfill, treated sanitary effluent, groundwater intercepted from the Interceptor Trench System (ITS), salt water solutions, wash water from the decontamination of production personnel, cyanide wastes, acid wastes and miscellaneous other compounds (DOE 1995f). Removal of pond sludge began in June 1985 and was completed for all SEPs by January 1995.

Note

The SEPs are on the eastern boundary of the pediment capped by the Rocky Flats Alluvium. Streams have eroded the pediment to the north and south with topographic relief of 50 to 100 feet. Much of the surficial deposits have been disturbed by construction of the SEPs, the ITS, nearby buildings and other infrastructure, however, borehole logs suggest that undisturbed Rocky Flats Alluvium often occurs below the disturbed ground.

Thickness of the unconsolidated material ranges from 0 to 25 feet, and averages about 10 feet. The Rocky Flats Alluvium overlies over the erosional bedrock surface and consist of poorly to moderately sorted gravel, sand, silt and clay with boulder to pebble size clasts derived from the nearby Front Range. Artificial fill was used as for road grade fill, berm construction, recontouring around engineered structures, and to fill in lows for the surface impoundments. Fill consisted of reworked Rocky Flats Alluvium with imported offsite materials including crushed rock, plus sandy clay and gravel with fragments of concrete rubble. The Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and fill materials. Claystone is the predominant subcropping lithology, but the No. 1 Sandstone subcrops in the vicinity of South Walnut Creek.

The shallow, unconfined groundwater occurs in unconsolidated surficial material and fractures in the underlying bedrock and the potentiometric surface generally mimics the surface topography. General flow direction is to the northeast under the SEPs. A bedrock high trending east-west under the SEPs diverts the northern flow to the north-northeast towards North Walnut Creek, and the southern flow to the east-southeast towards South Walnut Creek. Unsaturated areas are present over a large part of the area, in part due to the ITS. However, unsaturated areas to the south and east are not impacted by the ITS. The saturated thickness varies from 0 to 5 feet over most of the area, and is thinner along topographic highs, or on slopes where there are thin alluvium or colluvium deposits. Along North and South Walnut Creek, the saturated interval can be as much as 10 feet thick.

Interceptor Trench System

Hydraulic conductivity for the Rocky Flats Alluvium in this area is around 10^{-5} cm/sec. No data were given for the fill material. The hydraulic conductivities for the subcropping bedrock claystone ranges from 10^{-7} to 10^{-9} cm/sec. The hydraulic conductivities for the subcropping bedrock sandstone ranges from 10^{-5} to 10^{-6} cm/sec (DOE 1996b).

concentrations above background

~~There is~~ a large UHSU nitrate plume ~~that~~ extends north and east from the Solar Ponds to the North Walnut Creek drainage above Pond A-1. Uranium ~~is~~ are also found in the ~~contaminated~~ groundwater plume. A lobe of this nitrate plume extends to the southwest for a short distance. While the primary nitrate source has been removed for several years, this contaminant plume still contains nitrates at concentrations above 100 x MCLs. However, nitrate concentrations within the plume are decreasing with time. ~~The Interceptor Trench System~~ The ITS was installed to intercept contaminants and capture the nitrate plume. ~~and~~ It was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gallons of water per year, but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE 1994b).

VOC s ~~concentrations~~ are present in the groundwater at the western edge of the Solar Ponds Area. These are most likely related to the carbon tetrachloride spill from IHSS 118.1 discussed earlier. Carbon tetrachloride is present at well P210189, completed in ~~the~~ 9 4 feet depth? of silty sandstone believed to be the Arapahoe No. 1 Sandstone, at concentrations of 4,700 ug/l , tetrachloroethene at 1981 ug/l and trichloroethene at 2,200 ug/l. This subcropping sandstone could act as a conduit for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

PU&D Yard Plume

The PU&D Yard has been used since 1974 to store drums, cargo boxes and dumpsters. The PU&D Yard is located northwest of the industrial area in an area approximately 225 feet by 830 feet (Figure 1-1). Materials known to have been stored there include spent batteries, metal shavings coated with lathe coolant, and drums of spent solvents such as paint thinners and waste oils. Drummed hazardous material was also transferred in this area. Surface? Contamination exists from historical spills associated with past hazardous material transfer operations and storage at the site. Releases of battery acids and leaks from dumpsters and drums of spent solvents and waste oils have been reported.

The PU&D storage yard is underlain by the Rocky Flats alluvium which is approximately 25-30 feet thick in the vicinity. The alluvium is underlain by Arapahoe Formation claystone. Groundwater in this area flows to the east through the UHSU materials, mimicking the surface topography.

Recent soil gas investigations have verified the presence of volatile organic compounds immediately outside the eastern boundary of the PU&D storage yard. Organics, metals, and radionuclides have also been detected in surface soils (DOE 1995g). However, there are no subsurface samples of the soil and groundwater from this area.

An area of poorly defined, contaminated groundwater, with VOC concentrations slightly above the MCLs, is located downgradient of the PU&D Yard, and upgradient and to the south of the Present

Landfill. Further investigation is required to identify the source or determine whether there is ~~an~~ potential for impact to surface water quality.

Other 881 Hillside Groundwater Contamination

There are several one-time detects of VOCs in groundwater along the 881 Hillside (Figure 1-1). These do not seem to be related to a source, and may be more related to the problems of detecting very low levels of VOCs. In addition, there are two areas where contaminated groundwater has been identified, but where no action is required. Immediately adjacent to Building 881, there are sporadic detects of low concentrations of chlorinated solvents in groundwater. This suggests that several small point sources may exist in this area that are related to building operations.

The UHSU monitoring wells within the IHSS 119.2 drum storage area are dry or do not detect VOCs. However, there are infrequent detects of VOCs in groundwater sampled from two wells located within the drainage downgradient from IHSS 119.2. The source of these sporadic VOC detections may be the volatile plume derived from the 903 Pad.

In addition to the VOC contamination, the 881 Hillside groundwater contains dissolved or total ? selenium and vanadium at above background levels. Neither of these elements is a documented RFETS waste, nor requires remedial action to protect surface water.

Old Landfill Groundwater Contamination

The Old Landfill was in operation from 1952 to 1968 and was used to dispose of ~~around~~ approximately 2 million cubic feet of miscellaneous RFETS waste (Figure 1-1). Accurate and verifiable records of the material placed into this landfill are not available, but all of the waste material was considered non-hazardous at the time. However, paint, solvents, paint thinners, oil, pesticides, and cleaning agents were placed in the landfill as these were not considered hazardous in 1968. The landfill also received some beryllium, depleted uranium, and used graphite. The Old Landfill does not have a liner, but the underlying unweathered claystone has a permeability of 10^{-5} to 10^{-7} cm/sec. The landfill was closed with a soil cover sometime after 1968 and prior to 1980 (DOE 1996c).

Groundwater occurs in the surficial deposits, primarily in the landfill material and alluvium. Many groundwater samples were collected during the OU5 RFI/RI investigation from wells, hydropunch samples from boreholes, and one-time samples from well points. ~~However~~, the groundwater COCs identified for the Old Landfill are barium, manganese and radium, however, these do not correlate well with the waste known to be disposed at this site. ~~There are~~ two small areas of VOC contaminated groundwater are present in the Old Landfill area. One area is associated with a subsurface soil gas anomaly, the other is upgradient of the Old Landfill, probably related to the IA (section 4.2.6).

The OU5 RFI/RI soil gas investigation (DOE 1996c) located two, small, subsurface soil gas anomalies at the Old Landfill. One area is approximately 50 feet by 50 feet ~~with~~ and contains trichloroethene and 1,1,1-trichloroethene, and the other is about 64 feet by 64 feet ~~with~~ and contains tetrachloroethene and trichloroethene. Trichloroethene (maximum concentration of 19 ug/l) is sporadically detected in groundwater at one well associated with the larger anomaly. There are no VOCs in groundwater associated with the other anomaly.

~~unclear as this is~~ [illegible] soil gas

One well upgradient of the Old Landfill (P416789) has had three historical detects of TCE. This well is probably detecting contaminated groundwater from the Industrial Area Plume. Seep samples from a location immediately downgradient of this well also contained trace amounts of VOCs.

Walnut Creek Drainage Groundwater Contamination

~~There are~~ several wells in the area of the OU 6 trenches (IHSSs 166.1, 166.2 and 166.3) have detected ~~where~~ low-level VOC and metal groundwater contamination ~~is detected~~. Neither the subsurface soil samples taken from the OU 6 trench area nor the wells within the nearby Present Landfill contain the same contaminants found in the OU 6 wells which are located outside of the Present Landfill slurry wall. However, wells upgradient of the Present Landfill and outside of the slurry wall ~~do~~ exhibit similar contaminants and concentrations (see PU&D Yard plume above) (DOE 1996d and EG&G 1994).

There several theories for the occurrence of these low levels of VOCs and metals (DOE 1996d):

- The trenches (IHSSs 166.1 to 166.3) may be the source of contamination and the field investigation did not detect these sources,

- The Present Landfill is the source, and the southern intercept wall is inadequate,
- Wastes may have been emplaced beyond the southern slurry wall, or
- Contamination is from a source upgradient of the Present Landfill, potentially the PU&D yard.

VOC contaminated groundwater is found upgradient of the Present Landfill (average total VOC groundwater concentration of 71 ug/l), as well at this location (31 to 68 ug/l average total chlorinated hydrocarbons). In addition, well data indicates the south slurry wall is effective (EG&G 1994). Therefore, it is most likely that the contamination has migrated from a source upgradient of the Present Landfill. ~~groundwater~~

outside the slurry wall

4.3 CLEANUP ALTERNATIVES

The goal of this Groundwater Conceptual Plan is to manage and/or cleanup groundwater in order to be protective of surface water quality. The proposed cleanup of contaminated groundwater involves source removal or source containment, with treatment or management of the contaminated groundwater, to achieve this goal. Conceptual remedies for each major contaminant plume were developed by assessing the available technologies, and proposing a cost-effective, readily available technology. plumes

Both active and passive remedial actions were initially considered. Active treatment actions such as pump-and-treat methods are well-known and accepted, but typically have high operation and maintenance costs, can have a negative impact on wetlands, may consume groundwater, have limited application in clayey aquifers, and are relatively inefficient for DNAPL source removal. Passive treatment actions include passive collection of groundwater with *ex situ* or *in situ* treatment. These systems may have higher initial capital costs, but have lower operation and maintenance costs, low energy consumption, no water consumption, and reduced equipment requirements. Passive treatment will collect DNAPL contaminated groundwater, but also will not remove the source.

The pump-and-treat methodology is commonly used and accepted. EPA has identified the pump-and-treat methodology as one of the most frequently used methods for groundwater remediation, but recognizes that pump-and-treat methods may require decades of potentially expensive operations to achieve cleanup levels (EPA 1992). A preliminary analysis was performed on the potential effectiveness of pump-and-treat methods at RFETS. The analysis concluded that pump-and-treat methods would not be an effective treatment for most contaminant plumes at RFETS, based on the following:

- Neither the UHSU nor the LHSU are capable of producing significant quantities of water, because both have a relatively large clay content.

- Aquifer tests conducted at RFETS show that, for the most part, aquifer yields are low, ranging from 0.000006 gpm to 12 gpm, with an average of 0.3 gpm (EG&G 1995b).

- Factors limiting water production within the UHSU include relatively thin saturated thicknesses and the presence of broad areas that become unsaturated during the fall and early winter (EG&G 1995b).

- Surficial deposits at RFETS have hydraulic conductivities in the 10^{-3} to 10^{-4} cm/sec range, whereas weathered and unweathered claystone bedrock have hydraulic conductivities in the 10^{-7} cm/sec range. The valley-fill alluvium is the most permeable unit, but no contaminant sources are known to be present in this unit.

- Due to the relatively low permeability of the geologic units at RFETS, cones of depression induced by groundwater removal would typically have very steep gradients, requiring a large number of closely spaced wells to effectively implement pump-and-treat remediation.

- Upgradient extraction of groundwater may adversely impact the present widespread distribution of seeps and springs (EG&G 1995b).

- Most of the contaminant plumes in RFETS groundwater have suspected sources consisting of DNAPLs, which are difficult to remediate by using pump-and-treat or passive methods because:

- DNAPLs have low dissolution rates in water and are denser than water, and therefore tend to sink to the bottom of the unit.
- The high clay content tends to adsorb DNAPLs, making these difficult or impossible to remove.
- Pump-and-treat remediation leaves residual DNAPLs, which will continue to act as a source, further releasing dissolved contaminants to the groundwater system.

It may be possible to implement pump-and-treat methods for groundwater near the East Trenches, where the No. 1 Sandstone is contaminated. However, a large number of closely spaced wells would be required to effectively pump-and-treat groundwater due to the low conductivities and the resulting steep cones of depression. DNAPL contamination could easily remain after treatment. For these reasons, and the associated higher costs for this methodology, the pump-and-treat option was not considered as the proposed remediation treatment in this area.

When properly placed, a passive collection system near the distal ends of plumes will effectively capture the DNAPL-contaminated groundwater, but a contaminated plume would be left upgradient to naturally attenuate (DOE 1995h). The contaminants in the plume will degrade with time, and upgradient water will flush the source material toward the collection system.

All proposed actions discussed below were selected to be effective, inexpensive to install and operate, and require minimal plant infrastructure support. For these and the preceding reasons, passive treatment actions are the preferred proposed remediation.

Passive systems proposed for treatment of contaminant plumes in RFETS groundwater include:

- *In situ* passive collection and treatment system such as a funnel and gate, where contaminated groundwater is funneled into a reactive barrier by selective placement of relatively impermeable barriers. Treated water is released back into the groundwater downgradient of the barrier. Such treatment systems have been used effectively at other sites.

- Collection of contaminated water from springs, seeps, and/or shallow drains, then pumping the collected water to an existing treatment facility (Building 891 Combined Water Treatment Facility), and discharging the treated water to the surface water system.

- Passive collection of contaminated water from springs, seeps, and/or shallow drains, then using gravity to feed the collected water through a nearby, *ex situ* treatment system, which uses granulated activated carbon, reactive iron, or other simple treatment options such as air strippers.

The passive treatments proposed in this plan could use any of these methods and are conceptual in nature. No engineering feasibility analyses were performed and the proposed remedial actions were not evaluated with regard to changing site conditions over time. Before implementation of any remedy, an evaluation will be done to determine the most appropriate, effective, implementable, and cost-effective remedy for each plume of contaminated groundwater. The result of these evaluations will be presented as part of ASAP or in a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA), along with the data used to make the decision. It is possible that, as a result of these evaluations, different remedial actions will be selected for the different contaminant plumes in RFETS groundwater.

Assumptions

The proposed conceptual remedial actions for treatment of contaminated groundwater were developed using the following assumptions:

- RFETS groundwater will not be used for domestic or other consumptive purposes, and there are no pathways for contaminated groundwater to directly impact human receptors.

- Groundwater will be managed or remediated to protect surface water and to minimize potential ecological impacts due to entering the surface water system.

- Source removals or containment of subsurface soil sources will be designed to prevent further migration of groundwater containing contaminant concentrations greater than 100 x MCLs.

- Remediation and plume management will preserve wetlands where possible.

- Proposed actions will be implemented using cost-effective methodologies.

- Based on preliminary analysis, passive groundwater treatment or containment would appear to be the preferred remedial alternative for most contaminant plumes in RFETS groundwater.

- Performance monitoring will be conducted for all remediation systems to verify effectiveness.

- The remediation and management decisions described herein are based on the existing data set for contaminant plumes, as well as on known technologies that are believed to be applicable to treatment of RFETS groundwater.

- For this plan, the proposed actions are assumed to be passive treatment or containment devices. Passive treatment systems will be sited downgradient from the sources and coincident with the Tier I boundary within the plume, or where otherwise practicable and feasible. The actual remedial actions and location of these actions will be decided on a case-by-case basis and detailed in an IM/IRA or Proposed Action Memorandum (PAM) before implementation.

  abbreviated

- An alternatives analysis for any proposed action will be presented as part of ASAP or as an IM/IRA decision document.

- As per RFCA, contaminant plumes in RFETS groundwater which are stable and do not impact surface water above action levels will not require cleanup.

- All remedial actions will be consistent with the proposed end-state of RFETS.

4.4 POTENTIAL CLEANUP ACTIONS

Using available information, the following potential actions were conceptually developed for each major VOC contaminant plume in groundwater. As contaminated seeps are the most distal ends of these contaminated groundwater plumes, these will be managed through cleanup of groundwater sources, natural attenuation, and/or interception at or upgradient of seep locations in accordance with the action level framework and the ER ranking. Further analysis of alternatives for feasibility, cost effectiveness, and suitability must be performed before initiating any action. Figure 4-1 shows the conceptual location of the groundwater actions.

4.4.1 Potential Action for the 881 Hillside Drum Storage Area Plume

The final remedy proposed for OU 1 is to excavate those soils containing VOC concentrations greater than the Tier-I action levels. The volume of the source area requiring excavation is estimated at between 900 and 1,900 cubic yards of colluvium and weathered bedrock. Excavating the source will also remove much of the contaminated groundwater above Tier I action levels (Sampling and Analysis Report, 1996). After demonstrating that this proposed remedy has been effective, and that the source and much of the resulting contaminated groundwater have been removed, the French Drain and recovery well are expected to be removed from operation.

This remedial action will be protective of surface water quality, and should reduce or eliminate any potential long-term stress to environmental receptors of contaminants that may reach Woman Creek.

4.4.2 Potential Action for the Mound Site Plume

Cleanup of the Mound Site contaminated groundwater plume will consist of excavating the subsurface soil exceeding Tier-I action levels for soil cleanup criteria for VOCs. Contaminated materials in Trench T-1 will also be removed using the same criteria. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches South Walnut Creek. Interception of the contaminant plume will be accomplished by making improvements to the existing seep collection system at SW059. The contaminated water is expected to be treated by a passive system installed along the south bank of South Walnut Creek.

Containment and treatment of the contaminant plume in Mound Site groundwater will result in a reduction of risk to the environment posed by uncontrolled releases of contaminated groundwater to surface water.

4.4.3 Potential Action for the 903 Pad and Ryan's Pit Plume

The proposed action is to remove contaminant sources exceeding the Tier I soil action levels for VOCs in soil from the 903 Pad area. Removal of the subsurface soils in the Ryan's Pit area has

already been completed. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches Woman Creek. The contaminated water is expected to be treated by a nearby passive system.

4.4.4 Potential Action for the Carbon Tetrachloride Spill Plume

There are ~~two~~ three potential actions identified for this groundwater contaminant plume: (1) source removal by using shallow recovery wells to remove as much of the free-phase carbon tetrachloride as possible, and (2) removal of the contaminated soils, adjacent tanks, and associated piping. (3) insitu treatment such as steam stripping At this time, the building infrastructure in the area is containing this plume. Monitoring must continue to ensure that contaminated groundwater does not impact surface water. After removal of the infrastructure, near surface capture of this plume may be required to minimize impacts to surface water. If required, the captured water will be treated at a nearby passive treatment plant. This area may be capped as part of the 10-Year Plan. The impact on groundwater must be determined to see if additional controls are necessary.

4.4.5 Potential Action for the East Trenches Plume

Source remediation for Trenches T-3 and T-4 was completed in 1996 to remove subsurface soils that exceed the applicable RFETS soil cleanup criteria for VOCs. This action removed the contaminant source of this contaminated groundwater plume. The remedial action proposed for the remaining contaminated groundwater plume is to install a near-surface plume capture system near the distal end of the plume, and to use passive technologies to treat the contaminated groundwater.

4.4.6 Potential Action for the IA Plume

This groundwater contaminant plume may not require action because source removal and D&D activities should remove contaminant sources, the source of water in the plume will be reduced over time as capping and/or regrading and revegetation reduces infiltration, and water loss from the RFETS utilities will be eliminated. Monitoring must continue to ensure that contaminated groundwater does not migrate, or create a threat to surface water. An upgradient groundwater barrier is not recommended as preliminary calculations indicate that only 15 percent of the present recharge (precipitation plus groundwater influx) to the IA could be diverted by an upgradient barrier, preventing approximately 4 gallons per minute of groundwater flux from entering the IA.

4.4.7 Potential Actions for Additional Plumes

Present Landfill Plume

An interim remedial action has been installed at this location to collect the contaminated groundwater and leachate flowing from the landfill for treatment. This gravity-driven system consists of cement vaults for collecting the contaminated water. Treatment includes a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents. Contaminated water is treated to comply with established cleanup levels. This treatment should effectively mitigate the potential ecological risk from the contaminants of concern. The treatment system may change or be eliminated once the Present Landfill cap is installed, because groundwater migration may no longer be a concern.

Solar Ponds Nitrate Plume

Proposed remedial actions for the groundwater nitrate plume, if required, will be developed at a later date, based on final cleanup standards and site-specific hydrogeologic conditions. No source removal is planned for nitrate-containing media. However, a cap/cover is being considered, which would reduce the groundwater recharge and the flow through the nitrate-contaminated soils.

Recommendations from the Working Group, if approved by the Water Quality Control Commission (WQCC), will change the stream classification for nitrates from drinking water to agricultural. There is some possibility that this surface water will be used for irrigation. Measures are being implemented which will restrict use of this water for domestic use. If the drinking water classification is lifted, then the nitrate concentrations seen in the surface water as a result of the nitrate plume are acceptable for all of the remaining uses, and could be of benefit for irrigation.

PU&D Yard Plume

A limited field investigation will be completed in 1997 to determine the impact to surface water. This may be followed by a source removal the same year. The limited field investigation will determine whether groundwater remedial action(s) are required to protect surface water.

Other 881 Hillside Groundwater Contamination

No action is required to mitigate this plume as it is not impacting, or expected to impact surface water. Any point sources around the building are expected to be dealt with during building demolition.

Old Landfill Groundwater Contamination

The VOC contaminated groundwater associated with the Old Landfill is limited in extent, closely related to a small source area, and is not a threat to surface water quality. Therefore, this contaminated groundwater does not require any action.

Walnut Creek Drainage Groundwater Contamination

It is most likely that the contamination in this area has migrated from a source upgradient of the Present Landfill, potentially the PU&D Yard (see above). Contaminated groundwater in this area will be addressed as part of the remedy for the upgradient plume.

4.5 PLUME RANKING

Sources or contaminant plume above action levels that are determined to be candidates for remedial actions have been prioritized to determine the sequence in which remediation will occur. To accomplish this task, a methodology was developed by CDPHE, EPA, K-H, and RMRS staff to rank the known environmental risks at RFETS and is outlined in the "Environmental Restoration (ER) Ranking" (RMRS 1995).

The ER ranking is currently being updated to incorporate the new action levels. Sites are ranked using the following criteria: 1) concentrations of contaminants present in soil, subsurface soil, and groundwater; 2) impact to surface water; and 3) the potential for further release which quantifies the possibility that source material will continue to release contaminants into the environment. The resulting prioritized list is used to determine the general order in which to implement remedial actions.

This methodology incorporates a very conservative approach. As a result, IHSSs, areas and groundwater plumes where formal risk assessments have determined that there is no unacceptable risk may rank higher than expected on the prioritized list.

The Working Group recommended that the groundwater plumes be prioritized separately from the contaminant sources to allow the groundwater actions to be initiated separately from the source removal actions. The methodology for ranking the groundwater plumes follows:

1) **Action Level Framework Score**: ~~Analytical~~ data for VOCs in groundwater since 1990 were compared to the proposed Tier II action levels, and a ratio of the analytical result to Tier II action level value was calculated. The maximum ratio for each analyte within the contaminant plume was tabulated, and a total score for each groundwater plume was calculated by summing the maximum ratios. The resulting summed values were then converted to a Score Ratio using Table 4-1.

2) **Impact to Surface Water**: A rating of 1 to 3 was assigned to each plume based on the evaluation of whether or not the groundwater contaminant plume was impacting surface water at Tier I action levels (a rating of 3), had the potential to or was impacting surface water at Tier II levels (a rating of 2), or did not pose a threat to surface water at this time (a rating of 1).

3) **Potential for Further Release**: A rating of 1 to 3 is assigned based on an evaluation of whether or not there is a potential for contaminants to continue to migrate into groundwater (i.e., is an uncontained source present?). If there is probably free product present, a rating of 3 is assigned, if high concentrations of contaminant are present in soil, a rating of 2 is

assigned and if there is probably no uncontained source present, a rating of 1 is assigned. Because the groundwater plumes are ranked separately from the contaminant sources, and the contaminants are already in the groundwater, the potential for further release for all plumes is rated as a 1.

Table 4-1 Converstion Table for Scores

Summed Groundwater Ratios	*Score Ratio*
> 20,000	10
10,001 - 20,000	9
5,001 - 10,000	8
1,001 - 5,000	7
501 - 1,000	6
251 - 500	5
126 - 250	4
76 - 125	3
26 - 75	2
1 - 25	1

The ER Ranking was recalculated in September 1996 using the new action levels and standards, and including the groundwater contaminant plumes. Table 4-2 provides the ER rankings of the groundwater contaminant plumes within the ER Ranking.

Table 4-2 ~~Plume Ranking~~ Ranking of Groundwater Contaminant Plumes above Tier I Action Level

Plume	*ER Ranking*	*Comments*
Mound Site	6	
903 Pad and Ryan's Pit	10	Ryan's Pit source removed
East Trenches	11	Trenches T-3 and T-4 sources removed
PU&D Yard	15	
881 Hillside Drum Storage Area	17	
Carbon Tetrachloride Spill	18	
IA	20	
Solar Ponds	22	Ranking due to nitrate concentrations
Present Landfill	26	Groundwater presently collected/treated
~~Building 881 Area~~	~~28~~	~~Below Tier I action levels~~
~~Old Landfill~~	~~31~~	~~Below Tier I action levels~~

137

5.0 NEXT STEPS

Additional data must be collected and/or analyzed before implementing actions. Not all groundwater contaminant plumes and sources are characterized sufficiently to implement an action, and appropriate methodologies for collection and treatment must be identified. The ecological impacts of groundwater collection and treatment must be determined, as collection of the distal plume boundaries may irreparably damage wetlands and seeps.

Before implementation of any remedy, a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA) or PAM must be prepared, and an engineering design must be completed.

Based on the currently available information, following are the steps already completed towards groundwater remediation, and the proposed next steps. All of these activities have been proposed for funding within the next 5 years.

- Soils in OU 1 881 Hillside Drum Storage Area (IHSS 119.1) that contain contaminant concentrations above action levels may be excavated, removing material above the Tier I Action Level. Because the source of groundwater contamination would be removed, the use of the French Drain system and recovery well may no longer be necessary. After monitoring demonstrates the effectiveness of the remedy, these will be removed from service.

  The seep near Woman Creek will be evaluated to determine whether it is related to the 881 Hillside Drum Storage Area, and if there is an impact to surface water above action levels.

- The source of the Mound plume is anticipated to be remediated as an accelerated action. Pre-remedial investigations were completed in 1996 to delineate the extent of the contaminant source for this plume. Further pre-remedial investigations to determine the extent of the distal end of the groundwater contaminant plume, and effective, passive treatment methodologies are expected to continue in the near future. Gravity-flow passive treatment systems will be the preferred option.

- The sources of the 903 Pad and Ryan's Pit plume are scheduled to be removed. The Ryan's Pit source has already been characterized and remediated. Pre-remedial investigations are proposed to determine the extent of the source. The distal ends of the groundwater contaminant plumes require better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred option.

- A pre-remedial investigation is proposed for the carbon tetrachloride spill plume (IHSS 118.1) to better define the source, and to evaluate remedial actions. After the source is better defined, source removal is recommended. A limited pump and treat system may be installed due to the large amount of free product present in a limited area. If required, after removal of the surrounding buildings and associated footing drain systems, a passive collection and treatment system may be installed to contain the dissolved phase of this plume. This system would be located along the post-building removal, downgradient flow path near the impacted drainage.

- The sources for the East Trenches plume have been removed. Accelerated actions were completed in 1996 to excavate Trenches T-3 and T-4, and materials above the Tier I action levels were removed. The distal end of this groundwater contaminant plume requires better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred options.

- The IA plume will continue to be monitored to ensure that there is no increase in migration, and that there is no impact to surface water quality.

- Groundwater treatment systems need to be investigated to determine the optimum treatment methodology.

- The unknown extent of the chlorinated solvent plumes associated with the PU&D yard (IHSS 170, 174a, and 174b) is a data gap. Because the nature of the southern boundary of these plumes is undetermined, the potential impact to surface water cannot be evaluated. A limited characterization investigation is proposed for 1997 to determine the extent of the plume, and to determine the location, nature and size of the source material. Previous

investigations suggest that the contaminant source(s) may be located immediately east of the known PU&D yard boundary. Source removal is expected to follow in 1997 if a contaminant source can be defined.

- Soil vegetative caps or covers may be used throughout RFETS where necessary to limit natural recharge caused by precipitation from leaching of contaminants in the unsaturated zone and into groundwater. This would ~~greatly~~ reduce the movement of groundwater through the IA, and thereby reduce the mobility of the contaminant plumes. Subsurface sources of groundwater contamination would be removed where practical. At the end of the D&D/remediation phase, the plant water supply and sanitary sewer will be shut off. This will eliminate a major source of groundwater recharge for the IA, and should greatly reduce the mobility contaminant of the IA and carbon tetrachloride spill plumes.

  is this confirmed by [illegible] model ?

- A limited investigation is proposed for the Solar Ponds area to determine the extent of VOC contamination and whether there is a pathway to surface water. Carbon tetrachloride and trichloroethene are present at a well located near the western side of the SEPs. However, the extent of the contamination in the sandstone, and whether the sandstone subcrops in the North Walnut drainage are unknown.

Further analysis is required to determine optional intercept locations, actual treatment methodologies, and cost-effective project planning and scheduling.

The ER Ranking scheduled to be completed in 1996 and the proposed ranking of groundwater plumes presented in Section 4.5 provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

6.0 REFERENCES

DOE, 1992a, *Final Groundwater Assessment Plan*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, February.

DOE, 1992b, *Final Historical Release Report for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, June.

DOE, 1993, *Final Groundwater Protection and Monitoring Program Plan for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, October.

DOE, 1994a, *Final Phase III RFI/RI Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1)*, June 1994.

DOE, 1994b, *RCRA Report.*

DOE, 1995a, *Final Corrective Measures/Feasibility Study, Rocky Flats Environmental Technology Site 881 Hillside (Operable Unit No. 1),* February 1995.

DOE, 1995b, *Final Phase II RFI/RI Report, 903 Pad, Mound, and East Trenches Area, Operable Unit No. 2,* October 1995.

DOE, 1995c, *Draft Data Summary 2, Operable Unit No. 9, Outside Tanks,* October 1995.

DOE, 1995d, *Draft Data Summary 2, Operable Unit No. 13, 100 Area,* June 1995.

DOE, 1995e, *Draft Data Summary 1, Operable Unit No. 14, Radioactive Sites,* June 1995.

DOE, 1995f, *OU 4 Solar Evaporation Ponds, Proposed Interim Measure/Interim Remedial Action, Environmental Assessment Decision Document,* February 1995

DOE 1995g, *Technical Memorandum 1, Operable Unit No. 10, Other Outside Closures,* January 1995.

DOE, 1995h, *Intrinsic Remediation Monitoring Task 1 Evaluation Report,* U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, March 1995.

DOE 1996a, *Corrective and Remedial Action Proposed Plan, Rocky Flats Environmental Technology Site, Operable Unit 1 - 881 Hillside,* August 1996.

DOE 1996b, *OU 4 Solar Evaporation Ponds Phase II Ground Water Investigation, Final Field Program Report,* February 1996.

DOE 1996c, *Final Phase I RFI/RI Report Woman Creek Priority Drainage, Operable Unit 5,* April 1996.

DOE, 1996d, *Final Phase I RFI/RI Report Walnut Creek Priority Drainage, Operable Unit 6,* February 1996.

Driscoll, F. G., 1989, Groundwater and Wells, Third Printing, Johnson Division, St. Paul, Minnesota.

EG&G, 1992, *OU 2 Domestic Water Supply Simulations*, (Internal Report), EG&G Rocky Flats, Golden, Colorado, September, 9p.

EG&G, 1994, Technical Memorandum Final Work Plan OU 7, Volumes 1-4, RF/ER-94-00044, September.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

EG&G, 1995c, *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site*, Volume III of the Sitewide Geosciences Characterization Study, EG&G Rocky Flats, Golden, Colorado, January.

EG&G, 1995d, *1994 Well Evaluation Report for the Rocky Flats Environmental Technology Site (Final),* EG&G Rocky Flats, Golden, Colorado, March.

EPA, 1992, *Chemical Enhancements to Pump-and-Treat Remediation*, U.S. Environmental Protection Agency EPA/540/S-92/001.

EPA, 1994, *Draft Soil Screening Guidance*, U.S. Environmental Protection Agency, EPA/540/R-94/101.

RMRS, 1995, *Environmental Restoration Ranking*, RMRS Rocky Flats, Golden, Colorado, September 27.

RMRS, 1996a, *White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN*, report prepared for Kaiser-Hill Company, August 16, 1996.

RMRS 1996b, *Sampling and Analysis Report, Identification and Delineation of Contaminant Source Areas for Excavation Design Purposes, IHSS 119.1, OU 1*, April 1996

RMRS 1996c, *Trenches and Mound Site Characterization Report, RF/ER-96-00044.UN*, September 1996.

To: Distribution
From: Annette Primrose
Date: September 17, 1996

Subject: Review of the Draft Groundwater Conceptual Plan

Attached is a copy of the Draft Groundwater Conceptual Plan for your review. This document was originally submitted in March 1996, and has been revised to reflect changes in RFCA, and to include more information about groundwater plumes.

The table of contents, references and figures have not been finalized and are currently being revised. These are provided for your information only. The appendices have not been included, as these are derived from other documents and cannot be changed. In addition, all references to figures in the Landfill plume discussion will be deleted to be consistent with the other, non-Tier I plumes.

I would appreciate a quick turn-around on this document if possible. Please return comments as soon as possible, preferably by close of business Thursday.

Thank you for your assistance.

Distribution:

Greg DiGregorio
John Hopkins
John Law
~~Tim Lovseth~~

Looks real Good!

146

TABLE OF CONTENTS

147

FIGURES

TABLES

148

EXECUTIVE SUMMARY

The Groundwater Conceptual Plan provides a basis for cleanup and management of contaminated groundwater at the Rocky Flats Environmental Technology Site (RFETS) consistent with the Rocky Flats Cleanup Agreement (RFCA) Preamble, and the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils*. The Groundwater Conceptual Plan describes the management and cleanup of contaminated at RFETS. This plan was originally issued in March 1996, but has been revised to reflect the Final RFCA, and to include more groundwater plume data.

Addressing groundwater on a sitewide basis allows for effective coordination of groundwater activities, and provides consistency in addressing groundwater contamination. Because domestic use of groundwater at RFETS will be prevented through institutional controls, the goal is to manage or cleanup groundwater to protect surface water quality for all agreed-upon uses. In addition, the Groundwater Conceptual Plan identifies, describes, and ranks the principal groundwater contaminant plumes to provide a planning basis for funding, and implementation of groundwater actions.

The lateral extent and spread of contaminants in RFETS groundwater is limited by hydrogeologic conditions, therefore the contaminant plumes are relatively stable. In addition, groundwater discharges to surface water before leaving RFETS and there is a natural vertical barrier to downward migration of contaminated groundwater. Low-permeability claystones form a barrier at least 500-feet thick between contaminated groundwater at RFETS and the Laramie/Fox Hills aquifer.

The volatile organic compound (VOC) contaminant plumes in groundwater have the most potential to impact surface water, and are the primary focus of the Groundwater Conceptual Plan. Contaminant plumes with other, inorganic, constituents were addressed where surface water is impacted above action levels. A two-tiered approach for action levels was developed for groundwater and soils to be protective of surface water uses as well as to be protective of the ecological resources. The Tier I action levels were developed to identify potential cleanup targets. For groundwater, these were defined as 100 x Federal Drinking Water Maximum Contaminant Level (MCL) for VOCs. Tier II action levels were developed to identify contaminated groundwater that may impact surface water and were defined on the basis of exceedances above the MCL for individual constituents.

Six groundwater contaminant plumes have been identified where contaminant concentrations exceed the Tier I action levels. These contaminant plumes are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Site Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) Industrial Area Plume. In addition, other groundwater plumes do not exceed the Tier I action levels, but may have the potential to impact surface water. These additional plumes include the Present Landfill, Solar Ponds and Property Utilization and Disposal (PU&D) Yard plumes.

Nitrate ?

Proposed cleanup actions consist of source removal or containment, with capture and treatment or management of the contaminated groundwater. Using available information, potential actions were conceptually developed for each major groundwater contaminant plume. Based on capture and treatment effectiveness, installation and operating costs, and plant infrastructure requirements, passive captive and treatment methods were the preferred conceptual actions. Before each cleanup action can begin, analyses must be done to select the specific cleanup alternative, and to perform engineering design. Additional data may be needed to ensure the proper placement of cleanup systems.

The groundwater contaminant plumes were ranked based on the methodology previously developed to provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

The problem with naming the Carbon tet & Solar Ponds Nitrate plumes is that all the other plumes are named after areas — not constituents and that there are other principal constituents associated with these plumes

1.0 INTRODUCTION

The Groundwater Conceptual Plan was originally developed as a joint effort between the Department of Energy, Rocky Flats Field Office (DOE/RFFO), Kaiser-Hill Company, L.L.C. (K-H), Rocky Mountain Remediation Services, L.L.C. (RMRS), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). This plan incorporates the final Rocky Flats Cleanup Agreement (RFCA) (July 19, 1996), and guidance from the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils Working Group ("the Working Group"). This Working Group was formed to:

- Provide a basis for future decision making,
- Define the common expectations of all parties, and
- Incorporate land- and water-use controls into site cleanup.

The Groundwater Conceptual Plan was originally issued in March 1996, and has been revised to incorporate changes in RFCA, and additional information on plumes.

1.1 ROCKY FLATS CLEANUP AGREEMENT AND ACCELERATED SITE ACTION PROJECT (ASAP)

The RFCA was finalized between DOE/RFFO, EPA, and CDPHE to ensure the effective and efficient cleanup of RFETS. The RFCA Preamble mandates that environmental cleanup will be implemented through an integrated and streamlined regulatory approach. The RFCA preamble also defines the approximate areal extent of the five future conceptual land uses: (1) capped areas underlain by waste disposal cells or contaminated materials closed in-place, (2) an industrial-use area, (3) restricted open space, (4) restricted open space because of low levels of plutonium contamination in surface soils, and (5) unrestricted open space.

The RFCA Preamble states that the goal of soil and groundwater management and cleanup is the protection of surface water quality for the designated uses. Proposed actions will be designed to

protect ecological resources to protect the appropriate industrial or open space uses. Groundwater will not be used for any purposes at RFETS, except as related to cleanup activities.

ASAP was developed as a strategy to reduce risks and close RFETS. The strategy is being used to develop a comprehensive action plan implement the objectives of the RFCA Preamble and to ensure that, after cleanup, surface water and groundwater leaving the site will be acceptable for any use.

This Groundwater Conceptual Plan was developed using the conceptual RFCA Preamble objectives and the *Action Levels and Standards Framework for the Surface Water, Ground Water, and Soils*. It conceptually describes the management and cleanup of contaminated groundwater to protect surface water and ecological resources.

1.2 PURPOSE OF THE GROUNDWATER CONCEPTUAL PLAN AT RFETS

Groundwater at RFETS is present in the shallow, unconsolidated sediments and subcropping bedrock throughout the site. In the past, each Operable Unit (OU) investigated groundwater within its boundaries without addressing influences from upgradient sources. However, groundwater is not limited by OU or Individual Hazardous Substance Site (IHSS) boundaries. Several sources may contribute to a single groundwater plume, and groundwater plumes may cross several OUs and contribute to surface water contamination a great distance from the source location. Figure 1-1 shows the location of the principal areas discussed in the text.

The Groundwater Conceptual Plan addresses groundwater on a sitewide basis, in order to allow effective coordination of groundwater activities, and establishes a consistent approach to addressing groundwater contamination. While remediation of groundwater contaminant plumes must consider both the source and the associated groundwater plume, groundwater plume remediation can be performed independently of source remediation. Because there is no exposure pathway to humans from contaminated groundwater, the programmatic goals are to protect surface water and the environment, and limit potential contaminant migration (to the extent possible).

The three specific goals of the Groundwater Conceptual Plan are to:

1) Identify and describe the principal contaminant plumes in groundwater;

2) Rank the contaminant plumes for the purpose of establishing the priority for cleanup actions, in accordance with the method outlined in the "Environmental Restoration Ranking" (RMRS 1995); and

3) Provide an initial planning basis for funding and implementation of groundwater cleanup.

To meet these goals, the Groundwater Conceptual Plan proposes cleanup and/or management of contaminated groundwater through source removal, source control, and/or treatment of dissolved-phase plumes. Contaminated seeps are also addressed, as these represent the distal ends of the contaminated groundwater plumes. The Groundwater Conceptual Plan also recommends evaluating whether some areas of contaminated groundwater may remain in place, given that the programmatic goals can be met without active intervention.

1.3 DOCUMENT ORGANIZATION

The conceptual plan for groundwater restoration is presented in five sections: (1) Section 1.0 provides an introduction, describes the goals and purpose of the groundwater strategy, and presents the organization of the report; (2) Section 2.0 provides a summary background on groundwater at RFETS; (3) Section 3.0 presents the action levels and standards developed by the Working Group and describes the groundwater monitoring requirements; (4) Section 4.0 describes the various groundwater contaminant plumes present at RFETS and provides an overview of the proposed cleanup actions that may be used; and (5) Section 5.0 summarizes the proposed next steps.

This document also contains three appendices: (1) Appendix A is a list of acronyms used in this text, (2) Appendix B contains Attachment 5 to RFCA, the *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils*, and (3) Appendix C contains the executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company, August 16, 1996

2.0 HYDROGEOLOGY AT RFETS

A basic understanding of the hydrogeologic setting is important for evaluating the nature and distribution of contaminated groundwater at RFETS. The current reference documents for describing the sitewide geologic, hydrogeologic and groundwater geochemical data at RFETS are the "Geologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995a), the "Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995b), and the "Groundwater Geochemistry Report" (EG&G 1995c). Much of the following discussion was derived from these reports. Unpublished plume maps from the 1995 Well Evaluation Project were modified to generate the plume configuration maps in this report.

Figure 2-1 illustrates the geologic setting of RFETS. Conceptually, the shallow groundwater at RFETS flows through two separate water-bearing layers, known as hydrostratigraphic units. These units are defined based on observed differences in hydrologic and geochemical for each flow system. These units are generally referred to as the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). A third hydrostratigraphic unit, a permeable, deep regional artesian aquifer known as the Laramie-Fox Hills aquifer, lies below the LHSU and is used extensively as a water supply in the RFETS and greater Denver area. The RFETS hydrostratigraphic units are described in the greater detail in the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (EG&G 1995b).

The UHSU is the predominant water-bearing unit of concern at RFETS and is considered to be equivalent to the "uppermost aquifer" as defined by the Resource Conservation and Recovery Act (RCRA). It consists of unconsolidated, sandy and gravely materials mixed with clay (i.e., alluvium, colluvium, and artificial fill), as well as weathered bedrock claystones and sandstones which are hydraulically connected to the alluvium. The LHSU consists of unweathered claystone with some interbedded siltstones and sandstones. There is a significant difference in the ability of each unit to transmit groundwater. For example, the geometric mean hydraulic conductivity value of 2×10^{-4} centimeters per second (cm/sec) for the Rocky Flats Alluvium (UHSU) is about three orders of magnitude greater than that for unweathered LHSU Laramie claystones (geometric mean of 3×10^{-7} cm/sec). The hydraulic conductivities of LHSU materials are similar to that required for a landfill liner (EG&G 1995b). Wells completed in the UHSU and LHSU generally have poor water-yielding

155

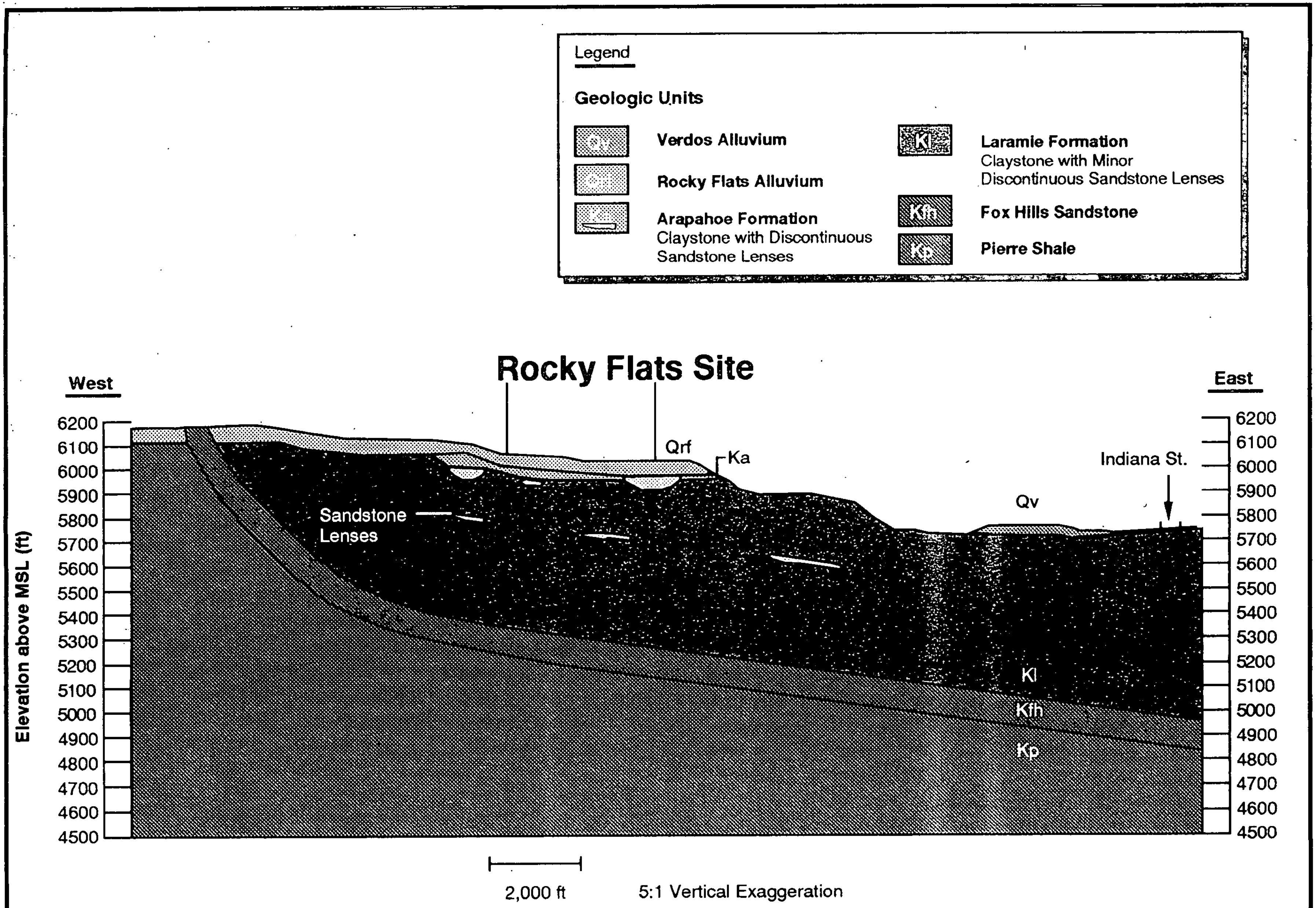


Figure 2-1 Generalized Geologic Cross-Section of the Rocky Flats Area

156

characteristics that prevent their development as viable water sources for residential use, although a few isolated UHSU well locations (i.e., bedrock sandstones in OU 2 (EG&G 1992) and valley-fill alluvium in Walnut Creek near Indiana Street (EG&G 1995d) have sustainable well yields that could support limited household use.

The spread of individual groundwater contaminant plumes at RFETS is limited by natural hydrogeologic conditions, including: the magnitude and distribution of hydraulic conductivities and hydraulic gradients; limited aquifer extent and interception of plume fronts by hydrologic boundaries (i.e., interception of groundwater contaminant plumes by drainages); and other physical controls, such as bedrock topography and the presence of discontinuously saturated areas, that constrain and moderate groundwater and contaminant movement.

Groundwater is estimated to flow slowly at RFETS. For example, using Darcy's Law, the velocity of groundwater moving laterally through the Rocky Flats Alluvium in the East Trenches Area is estimated to be about 50 feet per year (assuming a hydraulic conductivity of 217.3 ft/yr, effective porosity of 0.1, and hydraulic gradient of 0.0213 ft/ft).

Because natural processes such as sorption and geochemical transformation reactions tend to attenuate the movement of organic contaminant plumes in groundwater, the velocity of contaminant movement is expected to be retarded relative to the groundwater flow velocity. Contaminants in the East Trenches Plume would then be expected to migrate at rates ranging from about 2.5 and 25 feet per year, based on a reasonable range of retardation factors and neglecting the effects of dispersion and diffusion. Other processes may further attenuate contaminant movement, such as diffusion of aqueous contaminants into clayey matrix materials. Therefore, in some cases, plume front movement appears to be imperceptibly slow. The apparent slow migration rate of some contaminant plumes at RFETS, although not fully understood, provides a higher level of confidence that temporary deferment of remedial actions at these plumes will not result in undue risks to the environment.

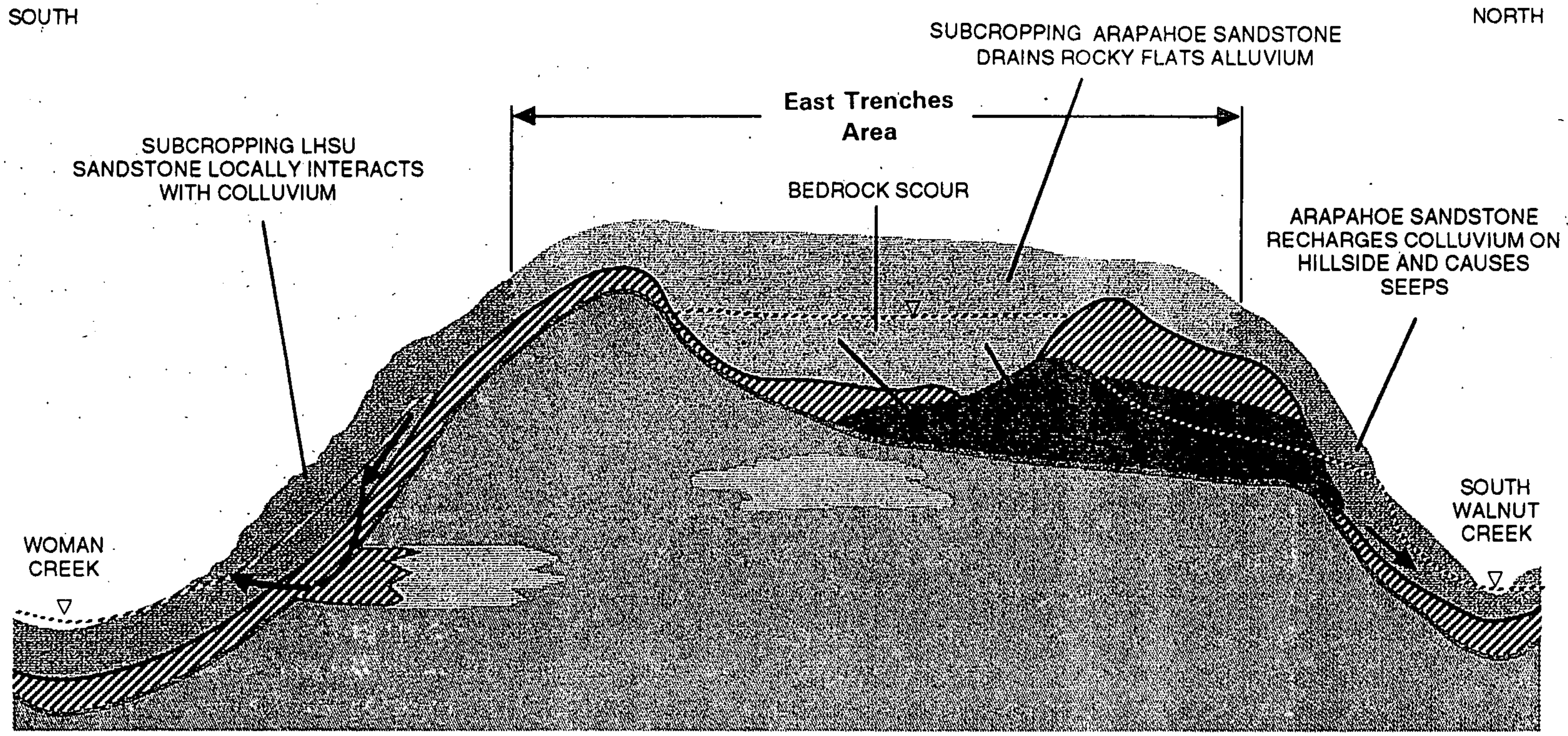
Groundwater in the surficial deposits of the UHSU generally flows to the east following bedrock and surface topography, and ultimately discharges to one of three stream drainages which are the main water pathways offsite. These drainages include Walnut and Woman Creeks, which receive

groundwater flow from the IA, and Rock Creek, which receives groundwater flow from areas essentially unimpacted by RFETS activities. Surface water flow from the IA is controlled by a series of impoundments in the Walnut and Woman Creek drainages. These impoundments also intercept groundwater flow associated with the valley-fill alluvium and promote intermingling of surface water with groundwater prior to release offsite. As a result, here is no known direct hydraulic connection between impacted groundwater at RFETS and offsite domestic wells.

In partially saturated areas, alluvial UHSU groundwater has been shown to preferentially flow along predepositional channels cut into the underlying bedrock surface (see Figure 2-2). These channels are known to occur in the IA, Solar Ponds, 881 Hillside, 903 Pad, and East Trenches Areas. Groundwater flow is often concentrated within these channels, and hillside contact seeps result where these channels are cut by erosional surfaces. These channels restrict plume spreading and movement. Other hydrogeologic controls for groundwater flow and contaminant transport are hydraulic gradient, distribution of subcropping sandstones and claystones, and topography. In the IA, features such as interceptor drain systems, buried utility lines, and building foundation drains control groundwater flow.

The lithologic and hydraulic characteristics of the LHSU cause it to act as a regional confining layer for the underlying Laramie-Fox Hills aquifer. The LHSU is a natural barrier to vertical groundwater flow and contaminant transport that effectively isolates impacted UHSU groundwater from deeper strata and the Laramie-Fox Hills aquifer (RMRS 1996a). At the IA the LHSU is estimated to measure at least 600 feet in thickness as shown in Figure 2-1 (modified from EG&G 1995a). By comparison, the average RCRA landfill is lined with only a few feet of similar material. These stratigraphic relationships, combined with an observed downward vertical hydraulic gradient, result in a LHSU groundwater flow regime that is predominantly vertically downward rather than horizontal. The available data from groundwater monitoring in the LHSU indicates that it is uncontaminated, with the exception of a few shallow LHSU wells with sporadic and, therefore suspect contaminant occurrences.

The available hydrogeologic and geochemical data suggest that fractures and faults are not significant conduits for downward vertical groundwater flow to deep aquifers (RMRS 1996a). Evidence of limited shallow hydraulic communication between UHSU and LHSU groundwater was found to exist in some wells, but these occurrences do not present a pattern consistent with known fault locations. Due to the thickness, lithology, and observed trend of decreasing hydraulic conductivity values with depth for the LHSU, it has been concluded that the LHSU has sufficient hydrologic integrity to provide long term protection of the Laramie-Fox Hills aquifer from shallow groundwater contamination (RMRS 1996). The executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN is presented in Appendix C and summarizes the hydrologic information used to reach the above conclusions.



EXPLANATION

- (Qrf) ROCKY FLATS ALLUVIUM
- (Qc) COLLUVIUM
- UNWEATHERED CLAYSTONE/ SILTSTONE BEDROCK
- WEATHERED BEDROCK
- WEATHERED ARAPAHOE #1 SANDSTONE BEDROCK
- LHSU UNWEATHERED SANDSTONE BEDROCK
- GROUND WATER FLOW DIRECTION
- CONCEPTUAL UHSU/LHSU BOUNDARY
- WATER TABLE

DRAFT OU2 PHASE II RFI/RI

Schematic Cross Section of Hydrostatigraphy at East Trenches Area

April 1995

Figure 2-2

160

g95\ES\hydrodoc\hydrostat cross-sectn..cdw

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for the action levels and standards developed by the Working Group. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and the Working Group considered all three media in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (July 19, 1996) is attached as Appendix B. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources. This framework for groundwater action levels is based on the conclusion that contaminated groundwater emerges as surface water before leaving RFETS.

Rads, metals nitrate } where do we stand?

3.2.1 Action Levels

The Working Group has defined the action levels, for Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated clean-ups, and Tier II action levels are protective of surface water quality. This approach is below.

Tier I

Tier I action levels were developed to identify potential cleanup targets in areas where VOC contamination of groundwater exceeds 100 times the MCL (100 x MCL). These action levels identify groundwater contaminant sources that present a higher potential risk to surface water quality that should potentially be addressed through an accelerated action. If Tier I action levels are exceeded, an evaluation is required to determine if remedial or management action is necessary to prevent the highly contaminated (i.e., contaminant concentrations exceeding 100 x MCLs) groundwater from reaching surface water (the evaluation process is described in Section 4.1). If action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination.

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of Appendix B. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. Figure 3-1 shows the location of Tier II monitoring wells relative to the composite VOC plumes as described in Section 4.2. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	1386
10194	10692
1986	4087
10994	B206989

163

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into a Integrated Monitoring ~~Groundwater Monitoring and Assessment~~ Plan (GMAP) IMP. The document will address all media and the groundwater portion will incorporate two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The ~~document~~ IMP will also describe ~~recent~~ proposed changes to the groundwater monitoring network.

The ~~GMAP~~ IMP will list the wells with their appropriate ~~regulatory driver~~ data quality objectives, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The ~~GMAP~~ IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, unless subsequent changes are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

Insert Figure 3-1

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water through groundwater transport of leached contaminants. The VOC contaminant plumes in subsurface soil and groundwater have the most potential to impact surface water. However, to provide cleanup guidance, action levels for inorganics that may be of concern at RFETS are currently under development in a manner consistent with that used for VOCs.

The soil VOC levels necessary to be protective of groundwater were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to determine the equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Using this approach, subsurface soil contaminant levels that would be protective of groundwater to 100 x MCLs were calculated and are presented in Appendix B.

4.0 GROUNDWATER CONTAMINANT PLUMES AND REMEDIATION

4.1 IDENTIFICATION

The VOC contaminated groundwater plumes at RFETS have the most potential to impact surface water or to migrate offsite as the mobility of VOCs in groundwater far exceeds the mobility of metals and radionuclides. These plumes were defined on the basis of the exceedances of the Tier II action levels and are shown on Figure 3-1. Tier I action levels were compared against all groundwater data to locate areas of highly contaminated groundwater. These areas were plotted and are shown on Figure 4-1 along with proposed locations of the conceptual groundwater actions.

The probable sources of the VOC contaminated groundwater plumes were identified using the available data and process knowledge. The flow diagram (see figure 4-2) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should be targeted for remedial action.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed Tier I action levels. In addition, there are several plumes and areas of interest where contaminant concentrations do not exceed Tier I action levels, or are of very limited extent, but that are of interest due their potential to impact surface water above RFCA action levels, or due to their contaminant concentrations. The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard.

The 903 Pad and Ryan's Pit Plume, the Mound Plume, and the East Trenches Plume are part of a large composite plume on the east side of RFETS. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

167

INSERT FIGURE 4-1

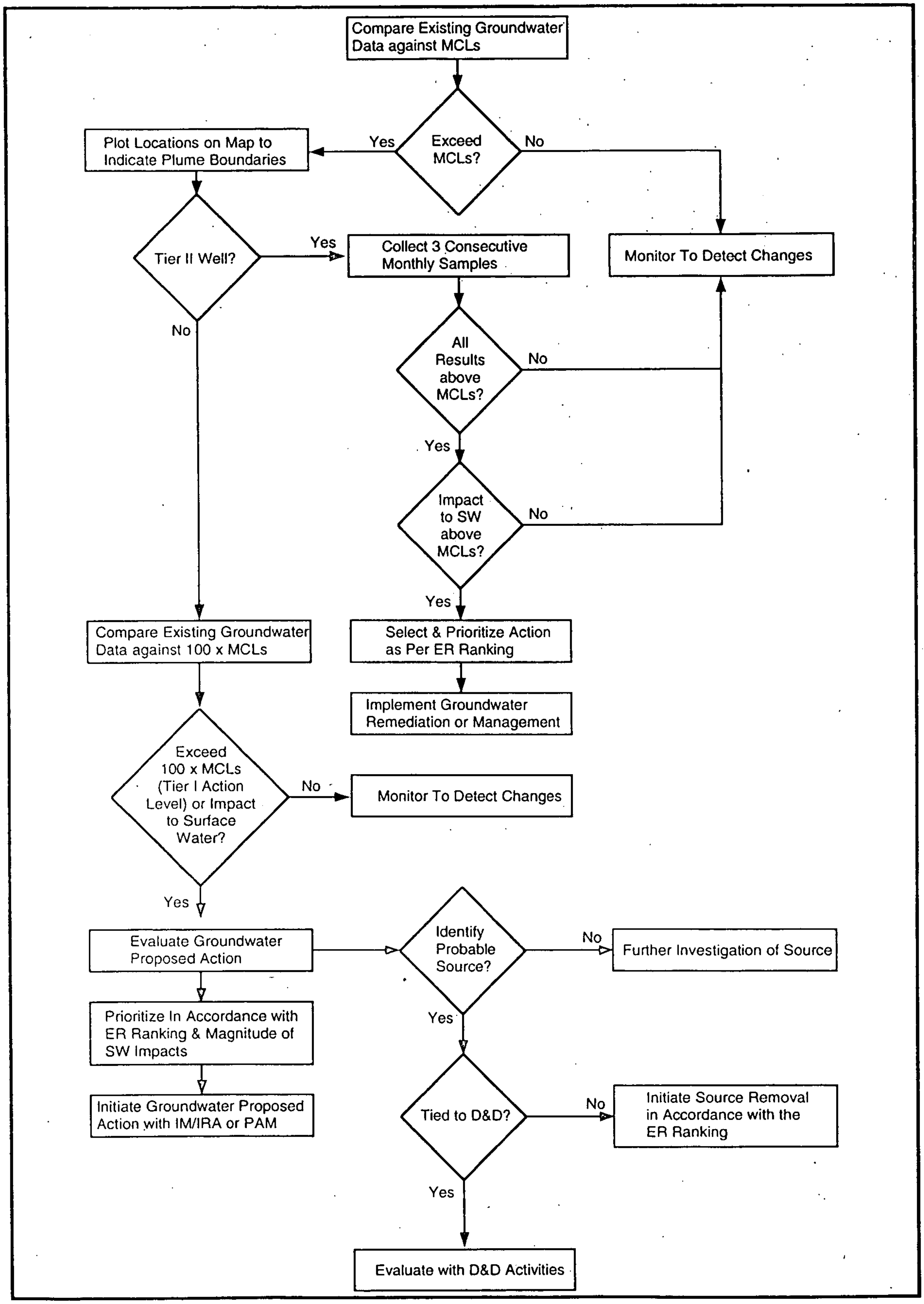


Figure 4-2 Flow Diagram

169

4.2 DESCRIPTIONS OF CONTAMINATED GROUNDWATER PLUMES

The extent of contaminated groundwater plumes in RFETS groundwater is not rapidly changing (see Section 2.0). The contaminated groundwater plumes are described below with much of the data derived from the relevant RFI/RI reports, data summaries, and the Hydrologic Characterization Report (EG&G, 1995).

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as the hotspots removed in 1994 from this location had elevated plutonium levels.

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek. The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

Here, groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (OU 1 CMS/FS, 1995).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are typically the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

alluvium. The bedrock topography and surficial deposit thickness can be used to extrapolate where groundwater flow may occur (OU 1 Phase III RFI/RI, 1994).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the hot, dry climate, slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3×10^{-3} to 2×10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2×10^{-6} m^2/sec, approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992.

Groundwater data collected since the installation of the French Drain suggests that it is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (OU 1 Phase III RFI/RI, 1994).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location. These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (figure a). The eastern source area underlies one of the radiological hot spots removed in 1994. Both source areas could easily have been caused by leakage from individual drums (Identification and Delineation of Contaminant Source Areas for Excavation Design Purposes, IHSS 119.1, OU 1, April 1996).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Table A provides the range of concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996).

4.2.2 Mound Site Plume

The Mound Site was used for as a disposal site for approximately 1,405 drums from April 1954 to September 1958. Drums contained depleted uranium, beryllium, lathe coolant (about 70% hydraulic oil and 30% carbon tetrachloride) and tetrachloroethene. Plutonium contaminated waste was also stored at this location, but plutonium levels were below detection limits. After it was noted that some of the drums were leaking, the drums were removed along with visibly stained soil. In addition, radioactive soils were removed at later dates.

172

The OU2 Phase II RFI/RI investigation identified acetone, methylene chloride, tetrachloroethene, trichloroethene and cis-1,3,-dichloropropene in the subsurface soils (OU 2 Phase II RFI/RI Report, 1995). Characterization results indicate increasing concentrations of tetrachloroethene and trichloroethene to a depth of 20 feet and decreasing concentrations below that depth. The recent Mound investigation delineated the area of contamination as occurring near borehole 14295 and well 1987, comprising approximately 400 cubic yards. (Mound Site Field Report September 1996)

The Mound Site is located at the northern edge of the pediment where up to 12 feet of Rocky Flats Alluvium overlies fractured claystone of the Arapahoe Formation. The topography slopes steeply to the north away from the Mound Site towards the incised drainage of South Walnut Creek. The Arapahoe No. 1 Sandstone subcrops under the alluvium at the northwest corner of the Mound Site. This sandstone is truncated by the South Walnut Creek drainage and subcrops beneath the colluvium between the Mound Site and South Walnut Creek.

In the vicinity of the Mound Site, the Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. The hill slope below the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation is covered with unconsolidated colluvium primarily composed of clay, or silty and/or sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Depth to groundwater is approximately 12 feet at the Mound Site (within the weathered bedrock), and unconsolidated materials are generally dry much of the year. Saturated alluvium occurs in bedrock lows and paleoscours in the top of the bedrock. The groundwater flow appears to be primarily along the bedrock surface and is probably controlled by small channels incised into the bedrock surface. Groundwater flows to the north through the No. 1 Sandstone until it subcrops beneath the colluvium, indicated by a line of seeps along the slope towards South Walnut Creek. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The

The maps you present support this statement, however, the direction of groundwater flow and the historic trends of constituents in the flow path seem to indicate that CaCa is coming from the 903 PAD. See data for Well 1787 & examine ~~the~~ any Spring potentiometric Surface map

geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration of precipitation or UHSU groundwater into the underlying unweathered claystone is limited.

Recharge occurs primarily through local infiltration of precipitation. The Central Avenue Ditch runs along the southern boundary of the Mound Site and probably also recharges the UHSU groundwater in this area. Discharge from the UHSU is mostly through seeps located where the water bearing units are truncated by the South Walnut Creek, and evapotranspiration.

The groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound Site, to a point of discharge along the south bank of South Walnut Creek, upstream of the RFETS Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound Site area are suspected to be the source of the groundwater contamination. There is a possibility that Trench T-1 could contribute to this plume; however, dry wells between the Trench T-1 and the Mound Site indicate that the Mound Site is the primary source of the contaminated groundwater plume. ??? There is little to no contribution from VOC contamination at the 903 Pad as upgradient wells in both the No. 1 Sandstone and alluvium contain 0 to 2 ug/l total VOCs.

Thirty-five VOCs were detected in the contaminated groundwater at the Mound Site. All except tetrachloroethene, trichloroethene, cis-1,2-Dichloroethene and vinyl chloride were below 100 ug/l. Tetrachloroethene was the predominant contaminant with the highest concentration of 13,000 ug/l found at the Mound Site. The maximum concentration of cis-1,2-DCE (214 ug/l) and trichloroethene (410 ug/l) was detected with the maximum tetrachloroethene value. Concentrations of these chemicals decrease towards South Walnut Creek. The maximum vinyl chloride concentration detected was 860 ug/l in a well along the South Walnut Creek drainage. The position of this well relative to the source suggests that vinyl chloride is a ~~indicating that this is a~~ degradation product, not a primary constituent.

The contaminant plume is discharging through surface and subsurface seeps along the hillside, and along seeps on the south bank of South Walnut Creek. At seep SW059, groundwater containing low levels of VOCs with trace amounts of radionuclides discharges at a rate of 0.5 gallons per minute, or less. The seep is collected and treated at the Building 891 Combined Water Treatment Facility.

175

4.2.3 The 903 Pad and Ryan's Pit Plume

This contaminant plume has two closely spaced sources: (1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and (2) Ryan's Pit where VOCs were disposed of in a trench. The 903 Pad was characterized as part of the OU 2 Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (RFI/RI) (DOE 1995) and the following information was derived from that report.

The 903 Pad area was used to store drums that contained radioactively contaminated oils and volatile organic compounds (VOCs) from the summer of 1958 to January 1967. Approximately three fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered by clean road base and an asphalt cap.

Ryan's Pit, previously referred to as Trench T-2, is located approximately 150 feet south of the 903 Pad. The dimensions of the pit are approximately 20 feet long, 10 feet wide, and five feet deep. The Pit was used as a waste disposal site from 1969 and 1971 for nonradioactive liquid chemical disposal. VOCs disposed at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only the liquids themselves were put in the pit; their containers were either reused or disposed of in other areas.

Materials placed in the Pit were supposedly screened for radionuclide activity prior to disposal. However, field investigations conducted in 1987 through 1993 do not substantiate this claim. The contaminated soils were removed from this site and treated during the 1995 removal action at Ryan's Pit. Free phase tetrachloroethene and motor fuel constituents were found during this removal action. Free phase DNAPLs are also suspected to exist underneath the 903 Pad as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's solubility).

The 903 Pad is located on the flat surface at the southern edge of the pediment. A south facing hillside slopes downward from the 903 Pad to the SID and Woman Creek. Ryan's Pit is located on the hillside about 200 feet from the southern edge of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The 903 Pad is paved with asphalt, and there is artificial fill present under the 903 Pad and over a large area to the south and east of the Pad. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds.

The Rocky Flats Alluvium is truncated by erosion and does not extend to the Ryan's Pit area. The Ryan's Pit area surficial deposits consist of reworked Rocky Flats Alluvium that has been transported down slope, along with other clay-rich colluvium deposits and fill material. Surficial deposits consist of colluvium between one and eight feet thick which is primarily clay, and silty or sandy clay. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. On the slope, there are numerous slump features with a large scarp face located between the 903 Pad and Ryan's Pit.

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at the extreme northwest corner of the 903 Pad. This sandstone is continuous with the Arapahoe No. 1 Sandstone at the Mound Site, where it is truncated by the South Walnut Creek drainage. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4}

cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thicknesses. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well-defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are fairly common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

A large bedrock low (paleoscour) extends from the 903 Pad east and passes directly south of the Northeast Trenches. This paleoscour is bounded by bedrock highs to the north and south. The paleoscour directs groundwater flow to the east till it is truncated by the South Walnut Creek drainage where alluvial groundwater discharges into the head of a well developed gully. Groundwater flow from the 903 Pad towards the SID and Woman Creek also occurs, either by overtopping of the lower, southern bedrock high, or through breaks in the bedrock high. During dry periods, the bedrock highs restrict alluvial groundwater flow to the south and north. During wet periods, when the alluvial groundwater levels are very high, flow may overtop these barriers, primarily to the south.

Groundwater flow in the colluvium follows north-south trending small paleochannels cut into the underlying bedrock claystone. One narrow paleochannel, approximately 150 to 300 feet wide, extends from the 903 Pad south through the Ryan's Pit area. The areas surrounding these paleochannels is unsaturated. The southern extent of groundwater flow is not well defined due to lack of well control.

Recharge is primarily from infiltration of precipitation along with some recharge from ditches and other surface water features. Wells located to the west of the 903 Pad are generally dry as alluvial groundwater inflow from the west is restricted by the claystone bedrock high just west of the 903

Pad. Unconsolidated materials within the medial portion of the paleoscour tend to be saturated, with the extent of saturation greatest during the Spring. Groundwater flow occurs through the No. 1 Sandstone until it subcrops beneath the colluvium. Discharge is primarily to seeps located where the water bearing units are truncated by the South Walnut Creek drainage. All UHSU groundwater is discharged to seeps or into the colluvium.

The 903 Pad and Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from these two source areas. This plume flows southward toward the SID and Woman Creek drainage. The lobe of contaminated groundwater which flows eastward from the 903 Pad is addressed as part of the East Trenches Plume.

Contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the alluvium and colluvium. Total VOC concentrations for the Arapahoe No. 1 Sandstone are approximately 2,500 ug/l adjacent to the west edge of the 903 Pad with concentrations at other locations less than 2 ug/l or non-detects. Fifty-seven VOCs were detected in UHSU groundwater for this plume. However, the primary contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene. The southern component of the contaminant plume derived from the 903 Pad contains total VOCs in the 5,000 ug/l range near the Pad, diminishing to 1,500 to 2,000 ug/l range upgradient of Ryan's Pit. Downgradient of Ryan's Pit, the total VOC concentration in groundwater ranges from 57,000 ug/l near the Pit to 5 ug/l near the distal end of the plume. The total VOC concentration in contaminated groundwater from the 903 Pad which does not also flow through the Ryan's Pit source is also estimated at 5 ug/l when it nears Woman Creek drainage.

The highest concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 ug/l) was detected immediately downgradient of Ryan's Pit and occurred with 1,1-dichloroethene at 380 ug/l. A well installed through the center of the 903 Pad contained concentrations of carbon tetrachloride in groundwater at 20,000 ug/l, chloroform at 39,000 ug/l and methylene chloride at 35,000 ug/l. A well installed though the northeast corner of the Pad detected tetrachloroethene at 14,000 ug/l. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although wells with VOC concentrations exceeding Tier I levels have been observed within the plume away from these sources.

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the South Interceptor Ditch and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit plume will reduce the risk to the environment posed by uncontrolled releases to surface water.

4.2.4 Carbon Tetrachloride Spill Plume

Carbon tet is the primary constituent however, degradation products as well as other chlorinated solvents are present.

The Carbon Tetrachloride Spill (IHSS 118.1) is located due north of Building 776 and east of Building 730. While there are other IHSSs that overlap IHSS 118.1, (IHSSs 121-Tank 9, 121-Tank 10, 131, and 144[N]), the contamination in the area is primarily related to the carbon tetrachloride spills.

yes, but you should mention the other constituents

IHSS 118.1 is the site where an underground, 5,000-gallon, carbon tetrachloride steel storage tank and the associated piping were formerly located. The tank was installed prior to 1970, and probably began leaking shortly after installation. Numerous spills occurred before 1970, some between 100 to 200 gallons (HRR DOE 1992b). The tank ultimately failed in June 1981, releasing carbon tetrachloride into the containment structure. The carbon tetrachloride was pumped from the containment structure to the surrounding ground surface, and the tank was removed along with a limited amount of soil surrounding the tank. The surrounding concrete containment structure was probably removed at this time also, but this has not been verified.

The surrounding area has numerous underground and overhead utilities and structures. These include clay sanitary sewer lines, electrical lines, tunnels between buildings, process waste lines and process waste tanks. Immediately east and partially overlapping this site is a group of four process waste tanks oriented east-west, tank groups T-9 and T-10. T-9 consists of two 22,500 gallon underground concrete storage tanks. T-10 consists of two 4,500 gallon concrete underground tanks. Both sets of tanks were installed in 1955, but are no longer used as process waste tanks. T-9 is currently being utilized as plenum deluge catch tanks for Building 776. No releases from either set has been documented (OU 9 data summary 1995).

180

Due to past construction activities in this area, the material overlying the claystone bedrock is predominantly fill material, probably derived from the Rocky Flats Alluvium, along with some remaining undisturbed Rocky Flats Alluvium. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

The recent IA investigation found free product in the subsurface soil and groundwater related to IHSS 118.1. All four of the soil borings drilled around T-9 and T-10 intercepted free-phase carbon tetrachloride (OU 9 data summary 1995). When a water sample was collected at this location, the liquid separated into two distinct phases. Other VOCs may be present, but the high concentrations of carbon tetrachloride may mask their detection. The top of bedrock surface prior to construction of Building 771 sloped to the northeast. Excavation during construction of this building altered this surface as the claystone surface was found 10 feet or more below where it was expected during the recent field investigations. Excavation may have either increased the slope of the bedrock surface, or created a bedrock low closed by the building. The bedrock in this area is claystone which limits vertical migration of the carbon tetrachloride. As carbon tetrachloride sinks to the lowest possible depth, the bedrock surface, building footing drains, and subsurface structures probably control the extent of the free-product plume and much of the dissolved phase portion of the contaminated groundwater plume.

Groundwater flow in this area is to the northeast towards Buildings 771 and 774 where there are known footing drains. Buildings 701 and 730 are not believed to have subsurface structures. Monitoring wells in the area contain carbon tetrachloride in the groundwater which indicates that a dissolved plume is present in the groundwater. This contaminated groundwater plume may eventually reach the North Walnut Creek drainage, especially after removal of the surrounding buildings.

Carbon tetrachloride and trichloroethene concentrations have been detected in a downgradient well completed in the Arapahoe No. 1 Sandstone at the western edge of the Solar Ponds, due east of IHSS 118.1. Carbon tetrachloride concentrations range from approximately 1,000 to 21,000 ug/l and the trichloroethene concentrations range from 2,000 to 8,000 ug/l. The concentrations fluctuate greatly

183

over time, but there is a general decreasing trend. The carbon tetrachloride spill is believed to be the source of this contamination and these contaminants indicate that there is some eastward movement of the dissolved phase of the plume. The decreasing trend over time may be a result of the VOCs in the vadose zone at the time of the spill, and settling to the bedrock surface, less in contact with groundwater over time.

The Solar Ponds area is in hydraulic connection with subcropping Arapahoe No. 1 Sandstone which could act as a conduit for the dissolved phase carbon tetrachloride plume. However, this sandstone is not known to subcrop or outcrop in drainages, and it appears that the risk to surface water is minimal.

(rephrase — just because our knowledge is minimal ~~is a poor reason~~ ~~to say there~~ is no risk.

4.2.5 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area, primarily associated with the trenches on the north side of the East Access Road. These trenches are known as the Northeast Trenches and include Trenches T-3, T-4, T-10 and T-11. Upgradient wells indicate a component of the contaminated groundwater in this area is derived from the VOC contamination in the 903 Pad (see section 4.2.3). However, the VOC concentrations in groundwater increase over 100 times after the groundwater passes through Trenches T-3 (IHSS 110) and T-4 (IHSS 111.1), indicating a VOC source is present.

Trench T-3 is located approximately 300 feet north of the East Access Road and immediately west of Trench T-4. Trench T-3 is approximately 134 feet long, 20 feet wide and 10 feet deep (HRR). Trench T-4 is approximately 110 feet long, 15 feet wide, and 10 feet deep (Trenches and Mound Site Characterization Report, RF/ER-96-00044.UN, RMRS 1996). The trenches were reportedly used sometime between 1954 to 1968 for disposal of sanitary sewage sludge, potentially contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. The trenches are also known to contain DNAPLs, crushed drums, and other miscellaneous waste. Activities of the trench material are below the RFETS soil put-back levels.

Trench T-3 and T-4 are located at the northern edge of the pediment where up to 18 feet of Rocky Flats Alluvium overlies fractured claystone and the No. 1 Sandstone of the Arapahoe Formation. Beyond the pediment boundary, the topography slopes steeply to the north towards South Walnut

184

Creek. Both the alluvium and the Arapahoe No. 1 Sandstone are truncated by the South Walnut Creek drainage.

The unconsolidated surficial deposits consist of the Rocky Flats Alluvium and artificial fill in the trenches and are generally dry. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. Thickness of the alluvium is approximately 18 feet at Trench T-4 and 16 feet at Trench T-3. Below the outcrop of the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation, the slope is covered with unconsolidated colluvium primarily composed of clay, or silty and sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Underlying the alluvium to the north of the trenches is the continuation of the claystone bedrock high from the 903 Pad area. The center of the associated paleoscour runs beneath Trenches T-11 and T-10 to the south of Trenches T-3 and T-4. This feature directs the surficial groundwater flow to the east, away from South Walnut Creek. However, the Arapahoe No. 1 Sandstone subcrops beneath the eastern portion of trench T-3 and most of Trench T-4. This fluvial sandstone is incised into the surrounding bedrock claystone and consists of sandstone, clayey sandstone, and silty sandstone. The channel of the Arapahoe Formation No. 1 Sandstone is approximately 40 feet thick and mostly saturated. Groundwater flow is generally unconfined, and flow within the channel is northward towards South Walnut Creek (EG&G 1995c). The sandstone subcrops beneath the colluvium between the trenches and South Walnut Creek at a spring and seep complex.

The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Arapahoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec and the geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Recharge of the Rocky Flats Alluvium is primarily through infiltration of precipitation, and upgradient flow from within the paleoscour. Recharge to the No. 1 Sandstone is from infiltration of precipitation through the surficial deposits, and some flow from upgradient. Discharge is primarily

185

to seeps and springs located where the water bearing units are truncated by South Walnut Creek, and by evapotranspiration.

Contaminated groundwater occurs in the alluvium and in the No. 1 Sandstone that is in hydraulic connection with the alluvium. While 27 VOCs were detected within the UHSU groundwater, the majority were detected at concentrations below 100 ug/l. The major contaminants are trichloroethene (maximum value of 94,000 ug/l), carbon tetrachloride (maximum value of 4,500 ug/l), and tetrachloroethene (maximum value of 1,000 ug/l). During the Soil Vapor Extraction Pilot Test Project, stratified water/NAPL samples were collected and analyzed from Trench T-3. Extremely high levels of VOCs were recorded, up to 37,000,000 ug/l for tetrachloroethene along with semivolatiles, petroleum compounds, and uranium-238 at concentrations up to 3,240 pCi/g (OU 2 Phase II RFI/RI, October 1995). In addition, during drilling activities, tetrachloroethene and trichloroethene were detected at concentrations of 12,000 and 1,000 ug/kg in Trench T-4.

The downgradient boundary of the contaminant plume is located at a spring and seep complex on the south bank of South Walnut Creek, above Ponds B-1 and B-2, where the No. 1 Sandstone subcrops. Concentrations of VOCs above 100 x MCLs have been detected by a recent sampling program conducted at the seep complex. There are potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

A lobe of this contaminant plume extends to the east of the East Trenches area along the paleoscour cut into the bedrock surface. However, contaminated groundwater has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored ensure that contaminated groundwater from this lobe does not impact surface water.

4.2.6 IA Plume

Several sources in the IA contribute trichloroethene, tetrachloroethene, and carbon tetrachloride to the contaminated groundwater plume in the IA. The plume is defined based on a small number of wells, and is thought to be principally confined to the east central side of the plant. It is not clear whether it is a large coalesced plume, or discrete areas of contaminated groundwater closely associated with individual source areas. The contaminated groundwater plume is outside of the fenced portion of the protected area (PA) and extends downgradient towards the central portion of the IA. Primary contaminant sources are described below.

IHSSs 117.1 was used as a general storage yard from before 1959 to the early 1970s and is located northeast of Building 551 (DOE, 1992b). The IA field investigations found elevated levels of tetrachloroethene (2,200 ug/l) during the soil gas survey, with less than 20 ug/l concentrations of trichloroethene and carbon tetrachloride and cis-1,2-dichloroethene. Elevated benzene, toluene, ethylbenzene and xylene (BTEX) levels are present in the southwest edge of the IHSS (OU 13 data summary).

IHSS 117.2, located east of Building 551, was used as a chemical storage site from prior to 1971 until approximately 1988. This site was used to store acids, oils, soaps, solvents, and beryllium scrap metal. Minor leaks and spills occurred. (HRR) The IA field investigations have determined the presence of elevated levels of 1,1-dichlorethene (2,700 ug/l) along with concentrations above 100 ug/l for vinyl chloride, cis-1,2 dichloroethene, trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Elevated concentrations of BTEX are also present (OU 13 data summary).

There have been numerous carbon tetrachloride spills within Building 776, and under building contamination is suspected. This building may be the source of downgradient low level concentrations of carbon tetrachloride in groundwater.

The IHSS 157.1 is adjacent to the Building 442 Laundry. Very low level concentrations (below 5 ug/l) of tetrachloroethene (PCE) were detected at this location (OU13 data summary).

IHSS 158 is an area where waste boxes were staged and loaded onto rail cars. This area is considered a radioactive site, and is located north of Building 551. Soil gas surveys found concentrations above 100 ug/l for vinyl chloride, toluene, and BTEX at this location (OU13 data summary).

IHSS 160 is a parking lot on the west side of Building 444. Drummed and boxed waste were stored at this location prior to paving, and leaked (HRR). The soil gas survey detected tetrachloroethene at 99 ug/l at this location. Concentrations less than 10 ug/l each of toluene, acetone, and benzene are also present (OU 14 Data Summary 1995).

IHSS 171 is a training area for fire department personnel. In the past, diesel, gasoline and possibly waste solvents were ignited for fire fighting training purposes. The area is currently in use, and a metal tree is used for burning propane for training. Large volumes of water are used during training which tends to accelerate migration of any contaminant plume. As expected, large concentrations of BTEX are present in the subsurface soils. Soil gas samples do not indicate high concentrations of VOCs. However, during drilling of a geoprobe hole in this IHSS, the rod came up coated with a brown liquid. Unfortunately, a sample could not be collected for analysis. It is possible that free product VOC does exist at this location (OU 13 data summary).

The hydrogeology of the IA has not been as extensively studied as other areas at RFETS. The Hydrogeologic Characterization Report (EG&G 1995) was the primary source for the following hydrogeologic information. The IA is located on a pediment capped by the Rocky Flats Alluvium. The pediment has been eroded at the sides to expose the underlying claystone of the Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. Fill material is abundant and usually consists of reworked Rocky Flats Alluvium. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

Groundwater occurs under unconfined conditions and flow is generally controlled by the topography of the underlying bedrock surface. Groundwater flow direction in the IA is generally eastward, with groundwater in the northern sections flowing to the northeast. Several building footing drain systems locally impact groundwater flow. Small bedrock channels are known to occur which direct the groundwater flow.

The IA groundwater plume is greatly influenced by the RFETS infrastructure. Groundwater recharge in the IA is from upgradient flow, infiltration of precipitation and substantial water losses from sewers and water-supply pipelines. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

The saturated thickness in the IA is typically 5 feet or less, with the greatest saturated thicknesses in the western part of the IA, decreasing to less than 5 feet in the eastern half of the IA. There are many unsaturated zones, particularly in the eastern half of the IA. These unsaturated areas are controlled by the bedrock, with bedrock highs generally dry. The decrease in saturated thickness in the eastern half of the IA may be caused by impermeable areas, such as parking lots and buildings, which greatly limit infiltration. Approximately 190 of 438 acres within the IA are covered by impermeable material. As a result, a greater amount of storm water runoff is channeled to permeable areas and may account for the large variations in saturated thickness.

Discharge from the IA is probably primarily to building footing drains, engineered structures such as the OU 1 French Drain and the Solar Ponds Interceptor Trench System, and potentially to seeps at the boundary of the IA. Both the Interceptor Trench and OU 1 French Drain have removed sufficient water from the surficial deposits to cause these to be locally unsaturated. Infiltration of groundwater into the underlying bedrock is generally limited due to the low hydraulic conductivity of the unweathered bedrock.

The IA groundwater contaminant plume extent is also controlled by interception of the plume by building footing drains and by the increased permeability and hydraulic conductivity through buried utility corridors. Full understanding of the migration of this plume depends on knowing how the various buildings, utility corridors, and sources interact. Unfortunately, there is insufficient knowledge of these factors to completely determine the configuration of this plume.

Figure X shows the average concentrations of VOC contaminants in the groundwater wells, and the probable contaminant sources. Treatment of contaminated groundwater within the IA does not appear to be necessary to protect surface water, because of the limited potential for migration. However, ongoing monitoring and evaluation of the groundwater will continue, to detect any possible movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand, migrate significantly or become a threat to surface water. Actions such as removal of buildings, removal of subsurface structures, and placing impermeable caps over areas must be examined to determine whether these will increase the movement of the contaminated groundwater plume. Controls may be required if increased groundwater contaminant plume movement results from these actions.

4.2.7 Additional Plumes and Areas of Contaminated Groundwater

There are several areas where there are sporadic occurrences of VOC contaminated groundwater, or where there are contaminant plumes with VOC concentrations less than 100 x MCLs. Contaminant plumes in the Present Landfill and Solar Ponds groundwater do not contain VOC concentrations greater than 100 x MCLs. However, these plumes are of interest because they are associated with RCRA units. In addition, a widespread but diffuse VOC plume is located near the PU&D Yard west of the Present Landfill. The setting and status of many of these plumes and occurrences are discussed below.

Present Landfill Plume

Operation of the Present Landfill (IHSS 114) for disposal of nonradioactive solid waste began in 1968 and will continue until the new landfill opens, or another method of waste disposal is available. The landfill covers an area of approximately 27 acres. The total volume of landfill material is approximately 415,000 cubic yards and consists of approximately 291,000 cubic yards of waste and 124,000 cubic yards of daily soil cover.

Elevated tritium and strontium concentrations were detected in leachate draining from the landfill in 1973. To control the migration, interim response actions were taken. Interim response activities included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill (West Landfill Pond and East Landfill Pond), a subsurface intercept system for diverting groundwater around the landfill and a subsurface leachate collection system. Between 1977 and 1981, the leachate collection and groundwater intercept system was buried beneath waste during landfill expansion. The lateral expansion of waste placement resulted in waste being located beyond the extent of the subsurface drains to the north and south. In 1982, two soil bentonite slurry walls were constructed to prevent groundwater migration into the expanded landfill area.

Leachate is a product of natural biodegradation, infiltration, precipitation, and migration of groundwater through waste. Approximately 5,756,000 gallons of leachate are present in landfill debris within the intercept system and above the unweathered claystone bedrock which is considered the underlying confining unit. The saturated thickness of surficial materials is greatest near the center of the landfill which suggests that recharge may be occurring by groundwater flow under or through the north groundwater intercept system (figure 4.2.7-1). Groundwater inflow may be occurring where the groundwater intercept system is not keyed into bedrock. Although an area of the south slurry wall is also not keyed into bedrock, well data indicates that it is effective in diverting groundwater.

During the Phase I RI/RFI investigation, 38 discrete groundwater samples were taken. In addition, 1990-1993 monitoring well data from 52 wells were used as the basis for determination of preliminary contaminants of concern. Groundwater in the UHSU at OU 7 contained metals, radionuclides, organic constituents and nitrates at concentrations higher than background (EG&G 1994).

The highest concentration of chlorinated hydrocarbons occurred in groundwater upgradient of the landfill. VOC contamination upgradient is composed entirely of chlorinated hydrocarbons. In contrast, average BTEX concentrations were highest in leachate collected from within the landfill. The BTEX compounds were not detected in upgradient groundwater. Different types of VOC contamination are presented within the landfill and upgradient (southwest) of the landfill, suggesting that a distinct source of VOC contamination is present upgradient of the landfill.

Two separate groundwater plumes exist in the vicinity of OU 7. The plume from the landfill source is located west of the landfill and is migrating down the No Name Gulch drainage. A second plume from an unknown source upgradient of the landfill is located in the groundwater south of the current landfill. The second plume is diverted around the southern slurry wall and then possibly migrates to the No Name Gulch drainage and/or Walnut Creek. A groundwater divide is located approximately 500 feet south of the southern slurry wall. Antimony, iron, manganese, tritium, uranium-238, chloromethane, ethylbenzene, and vinyl chloride concentrations in the groundwater exceed the Groundwater Tier II Action Levels. Because of the proximity to No Name Gulch, monitoring and further evaluation is required.

Solar Ponds Nitrate Plume Consider naming This plume — Solar Ponds Plume

The Solar Evaporation Ponds (SEPs) consists of five surface water impoundments. From 1953 to 1986, these were used to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. The materials placed into the SEPs included radioactively contaminated aluminum scrap metal, alcohol wash solutions, drums of waste radiography solutions, leachate from the Present Landfill, treated sanitary effluent, groundwater intercepted from the Interceptor Trench System (ITS), salt water solutions, wash water from the decontamination of production personnel, cyanide wastes, acid wastes and miscellaneous other compounds (OU 4 Proposed IM/IRA-EA Decision Document, February 10, 1995). Removal of pond sludge began in June 1985 and was completed for all SEPs by January 1995.

The SEPs are on the eastern boundary of the pediment capped by the Rocky Flats Alluvium. Streams have eroded the pediment to the north and south with topographic relief of 50 to 100 feet. Much of the surficial deposits have been disturbed by construction of the SEPs, the ITS, nearby buildings and other infrastructure, however, borehole logs suggest that undisturbed Rocky Flats Alluvium often occurs below the disturbed ground.

Thickness of the unconsolidated material ranges from 0 to 25 feet, and averages about 10 feet. The Rocky Flats Alluvium overlies over the erosional bedrock surface and consist of poorly to moderately sorted gravel, sand, silt and clay with boulder to pebble size clasts derived from the nearby Front Range. Artificial fill was used as for road grade fill, berm construction, recontouring around engineered structures, and to fill in lows for the surface impoundments. Fill consisted of reworked Rocky Flats Alluvium with imported offsite materials including crushed rock, plus sandy clay and gravel with fragments of concrete rubble. The Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and fill materials. Claystone is the predominant subcropping lithology, but the No. 1 Sandstone subcrops in the vicinity of South Walnut Creek.

The shallow, unconfined groundwater occurs in unconsolidated surficial material and fractures in the underlying bedrock and the potentiometric surface generally mimics the surface topography. General flow direction is to the northeast under the SEPs. A bedrock high trending east west under the SEPs diverts the northern flow to the north-northeast towards North Walnut Creek, and the

192

southern flow to the east-southeast towards South Walnut Creek. Unsaturated areas are present over a large part of the area, in part due to the ITS. However, unsaturated areas to the south and east are not impacted by the ITS. The saturated thickness varies from 0 to 5 feet over most of the area, and is thinner along topographic highs, or on slopes where there are thin alluvium or colluvium deposits. Along North and South Walnut Creek, the saturated interval can be as much as 10 feet thick.

Hydraulic conductivity for the Rocky Flats Alluvium in this area is around 10^{-5} cm/sec. No data were given for the fill material. The hydraulic conductivities for the subcropping bedrock claystone ranges from 10^{-7} to 10^{-9} cm/sec. The hydraulic conductivities for the subcropping bedrock sandstone ranges from 10^{-5} to 10^{-6} cm/sec (OU 4 Solar Evaporation Ponds Phase II Ground Water Investigation Final Field Program Report DOE February 1996).

There is a large UHSU nitrate plume that extends north and east from the Solar Ponds to the North Walnut Creek drainage above Pond A-1. A lobe of this nitrate plume extends to the southwest for a short distance. While the primary nitrate source has been removed for several years, this contaminant plume still contains nitrates at concentrations above 100 x MCLs. However, nitrate concentrations within the plume are decreasing with time. The Interceptor Trench System (ITS) was installed to intercept contaminants and capture the nitrate plume and was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gallons of water per year, but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE 1994).

VOC concentrations are present in the groundwater at the western edge of the Solar Ponds Area. These are most likely related to the carbon tetrachloride spill from IHSS 118.1 discussed earlier. Carbon tetrachloride is present at well P210189, completed in the 4 feet of silty sandstone believed to be the Arapahoe No. 1 Sandstone, at concentrations of 4,700 ug/l , tetrachloroethene at 1981 ug/l and trichloroethene at 2,200 ug/l. The extent of the contamination in the sandstone is unknown due to lack of well control. However, the other wells completed in this sandstone in the Solar Ponds area do not contain VOC contaminated groundwater. This sandstone does not appear to subcrop in the North Walnut drainage, and therefore does not provide a pathway to surface water. Uranium is also found in the Solar Ponds contaminated groundwater plume.

need to address The Uranium story

193

PU&D Yard Plume

The PU&D Yard has been used since 1974 to store drums, cargo boxes and dumpsters. The PU&D Yard is located northwest of the industrial area in an area approximately 225 feet by 830 feet. Materials known to have been stored there include spent batteries, metal shavings coated with lathe coolant, and drums of spent solvents such as paint thinners and waste oils. Drummed hazardous material was also transferred in this area. Contamination exists from historical spills associated with past hazardous material transfer operations and storage at the site. Releases of battery acids and leaks from dumpsters and drums of spent solvents and waste oils have been reported.

The PU&D storage yard is underlain by the Rocky Flats alluvium which is approximately 25-30 feet thick in the vicinity. The alluvium is underlain by Arapahoe Formation claystone. Groundwater in this area flows to the east through the UHSU materials mimicking the surface topography.

Recent soil gas investigations have verified the presence of volatile organic compounds in the vadose and down the hillside zone, concentrated just outside the east and northern boundary of the PU&D storage yard. Organics, metals, and radionuclides have also been detected in surface soils (OU 10 data summary). However, subsurface investigations of the soil and groundwater have not been conducted.

An area of poorly defined, contaminated groundwater, with VOC concentrations slightly above the MCLs, is located downgradient of the PU&D Yard, and upgradient and to the south of the Present Landfill. Further investigation is required to identify the source or determine whether there is an impact to surface water quality.

Other 881 Hillside Groundwater Contamination

There are several one-time detects of VOCs in groundwater along the 881 Hillside. These do not seem to be related to a source, and may be more related to the problems of detecting very low levels of VOCs. In addition, there are two areas where contaminated groundwater has been identified, but where no action is required. Immediately adjacent to Building 881, there are sporadic detects of low concentrations of chlorinated solvents in groundwater. This suggests that several, small point sources may exist in this area related to building operations.

The UHSU monitoring wells within the IHSS 119.2 drum storage area are dry or do not detect VOCs. However, there are infrequent detects of VOCs in groundwater sampled from two wells located within the drainage downgradient from IHSS 119.2. The source of these sporadic VOC detections may be the volatile plume derived from the 903 Pad.

In addition to the VOC contamination, the 881 Hillside groundwater contains selenium and vanadium at above background levels. Neither of these elements is a documented RFETS waste, nor requires remedial action to protect surface water.

Old Landfill Groundwater Contamination

The Old Landfill was in operation from 1952 to 1968 and was used to dispose of around 2 million cubic feet of miscellaneous RFETS waste. Accurate and verifiable records of the material placed into this landfill are not available, but all of the waste material was considered non-hazardous at the time. However, paint, solvents, paint thinners, oil, pesticides, and cleaning agents were placed in the landfill as these were not considered hazardous in 1968. The landfill also received some beryllium, depleted uranium, and used graphite. The Old Landfill does not have a liner, but the underlying unweathered claystone has a permeability of 10^{-5} to 10^{-7} cm/sec. The landfill was closed with a soil cover sometime after 1968 and prior to 1980 (OU5 Phase I RFI/RI Report, April 1996).

Groundwater occurs in the surficial deposits, primarily in the landfill material and alluvium. A large number of groundwater samples were collected during the OU5 RFI/RI investigation from wells, hydropunch samples from boreholes, and one-time samples from well points. The groundwater COCs identified by the OU 5 risk assessment for the Old Landfill are barium, manganese and radium, however, these do not correlate well with the waste disposed at this site. There are two small areas of VOC contaminated groundwater in the Old Landfill area. One area is associated with subsurface soil gas anomalies, and the other area is upgradient of the Old Landfill, probably related to the IA plume (section 4.2.6).

The OU5 RFI/RI soil gas investigation (DOE 1996) located two, small, subsurface soil anomalies at the Old Landfill. One area is approximately 50 feet by 50 feet with trichloroethene and 1,1,1-trichloroethene, and the other is about 64 feet by 64 feet with tetrachloroethene and trichloroethene. Trichloroethene (maximum concentration of 19 ug/l) is sporadically detected in groundwater at one of the wells associated with the larger anomaly. There are no VOCs in groundwater associated with the other anomaly.

One well upgradient of the Old Landfill (P416789) has had three historical detects of TCE. This well is probably detecting contaminated groundwater from the Industrial Area Plume. Seep samples from a location immediately downgradient of this well also contained trace amounts of VOCs.

Walnut Creek Drainage Groundwater Contamination

There are several wells in the area of the OU 6 trenches (IHSSs 166.1, 166.2 and 166.3) where low-level VOC and metal groundwater contamination is detected. Neither the subsurface soil samples taken from the OU 6 trench area nor the wells within the nearby Present Landfill contain the same contaminants found in the groundwater, and the OU 6 wells are located outside of the Present Landfill slurry wall. However, wells upgradient of the Present Landfill and outside of the slurry wall do exhibit similar contaminants and concentrations (see PU&D Yard plume above) (OU 6 RFI/RI Report, February 1996 and EG&G, 1994).

There several theories for the occurrence of these low levels of VOCs and metals (OU 6 RFI/RI):

- The trenches (IHSSs 166.1 to 166.3) may be the source of contamination and the field investigation did not detect these sources,
- The Present Landfill is the source, and the southern intercept wall is inadequate,
- Wastes may have been emplaced beyond the southern slurry wall, or
- Contamination is derived from a source upgradient of the Present Landfill, potentially the PU&D yard.

It is most likely that the contamination has migrated from a source upgradient of the Present Landfill. because ?

196

4.3 CLEANUP ALTERNATIVES

The goal of this Groundwater Conceptual Plan is to manage and/or cleanup groundwater in order to be protective of surface water quality. The proposed cleanup of contaminated groundwater involves source removal or source containment, with treatment or management of the contaminated groundwater, to achieve this goal. Conceptual remedies for each major contaminant plume were developed by assessing the available technologies, and proposing a cost-effective, readily available technology.

Both active and passive remedial actions were initially considered. Active treatment actions such as pump-and-treat methods are well-known and accepted, but typically have high operation and maintenance costs, can have a negative impact on wetlands, may consume groundwater, have limited application in clayey aquifers, and are relatively inefficient for DNAPL source removal. Passive treatment actions include passive collection of groundwater with *ex situ* or *in situ* treatment. These systems may have higher initial capital costs, but have lower operation and maintenance costs, low energy consumption, no water consumption, and reduced equipment requirements. Passive treatment will collect DNAPL contaminated groundwater, but also will not remove the source.

The pump-and-treat methodology is commonly used and accepted. EPA has identified the pump-and-treat methodology as one of the most frequently used methods for groundwater remediation, but recognizes that pump-and-treat methods may require decades of potentially expensive operations to achieve cleanup levels (EPA 1992). A preliminary analysis was performed on the potential effectiveness of pump-and-treat methods at RFETS. The analysis concluded that pump-and-treat methods would not be an effective treatment for most contaminant plumes at RFETS, based on the following:

- Neither the UHSU nor the LHSU are capable of producing significant quantities of water, because both have a relatively large clay content.

- Aquifer tests conducted at RFETS show that, for the most part, aquifer yields are low, ranging from 0.000006 gpm to 12 gpm, with an average of 0.3 gpm (EG&G 1995b).

- Factors limiting water production within the UHSU include relatively thin saturated thicknesses and the presence of broad areas that become unsaturated during the fall and early winter (EG&G 1995b).

- Surficial deposits at RFETS have hydraulic conductivities in the 10^{-3} to 10^{-4} cm/sec range, whereas weathered and unweathered claystone bedrock have hydraulic conductivities in the 10^{-7} cm/sec range. The valley-fill alluvium is the most permeable unit, but no contaminant sources are known to be present in this unit.

- Due to the relatively low permeability of the geologic units at RFETS, cones of depression induced by groundwater removal would typically have very steep gradients, requiring a large number of closely spaced wells to effectively implement pump-and-treat remediation.

- Upgradient extraction of groundwater may adversely impact the present widespread distribution of seeps and springs (EG&G 1995b).

- Most of the contaminant plumes in RFETS groundwater have suspected sources consisting of DNAPLs, which are difficult to remediate by using pump-and-treat or passive methods because:

  - DNAPLs have low dissolution rates in water and are denser than water, and therefore tend to sink to the bottom of the unit.
  - The high clay content tends to adsorb DNAPLs, making these difficult or impossible to remove.
  - Pump-and-treat remediation leaves residual DNAPLs, which will continue to act as a source, further releasing dissolved contaminants to the groundwater system.

It may be possible to implement pump-and-treat methods for groundwater near the East Trenches, where the No. 1 Sandstone is contaminated. However, a large number of closely spaced wells would be required to effectively pump-and-treat groundwater due to the low conductivities and the resulting

198

steep cones of depression. DNAPL contamination could easily remain after treatment. For these reasons, and the associated higher costs for this methodology, the pump-and-treat option was not considered as the proposed remediation treatment in this area.

When properly placed, a passive collection system near the distal ends of plumes will effectively capture the DNAPL-contaminated groundwater, but a contaminated plume would be left upgradient to naturally attenuate (DOE 1995). The contaminants in the plume will degrade with time, and upgradient water will flush the source material toward the collection system.

All proposed actions discussed below were selected to be effective, inexpensive to install and operate, and require minimal plant infrastructure support. For these and the preceding reasons, passive treatment actions are the preferred proposed remediation.

Passive systems proposed for treatment of contaminant plumes in RFETS groundwater include:

- *In situ* passive collection and treatment system such as a funnel and gate, where contaminated groundwater is funneled into a reactive barrier by selective placement of relatively impermeable barriers. Treated water is released back into the groundwater downgradient of the barrier. Such treatment systems have been used effectively at other sites.

- Collection of contaminated water from springs, seeps, and/or shallow drains, then pumping the collected water to an existing treatment facility (Building 891 Combined Water Treatment Facility), and discharging the treated water to the surface water system.

- Contaminated water collection from springs, seeps, and/or shallow drains, then using gravity to feed the collected water through a nearby, *ex situ* treatment system, which uses granulated activated carbon, reactive iron, or similar treatment options.

The passive treatments proposed in this plan could use any of these methods and are conceptual in nature. No engineering feasibility analyses were performed and the proposed remedial actions were not evaluated with regard to changing site conditions over time. Before implementation of any remedy, an evaluation will be done to determine the most appropriate, effective, implementable, and cost-effective remedy for each plume of contaminated groundwater. The result of these evaluations will be presented as part of ASAP or in a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA), along with the data used to make the decision. It is possible that, as a result of these evaluations, different remedial actions will be selected for the different contaminant plumes in RFETS groundwater.

Assumptions

The proposed conceptual remedial actions for treatment of contaminated groundwater were developed using the following assumptions:

- RFETS groundwater will not be used for domestic or other consumptive purposes, and there are no pathways for contaminated groundwater to directly impact human receptors.
- Groundwater will be managed or remediated to protect surface water and to minimize potential ecological impacts due to entering the surface water system.
- Source removals or containment of subsurface soil sources will be designed to prevent further migration of groundwater containing contaminant concentrations greater than 100 x MCLs.
- Remediation and plume management will preserve wetlands where possible.
- Proposed actions will be implemented using cost-effective methodologies.
- Based on preliminary analysis, passive groundwater treatment or containment would appear to be the preferred remedial alternative for most contaminant plumes in RFETS groundwater.
- Performance monitoring will be conducted for all remediation systems to verify effectiveness.

200

- The remediation and management decisions described herein are based on the existing data set for contaminant plumes, as well as on known technologies that are believed to be applicable to treatment of RFETS groundwater.

- For this plan, the proposed actions are assumed to be passive treatment or containment devices. Passive treatment systems will be sited downgradient from the sources and coincident with the Tier I boundary within the plume, or where otherwise practicable and feasible. The actual remedial actions and location of these actions will be decided on a case-by-case basis and detailed in an IM/IRA or Proposed Action Memorandum (PAM) before implementation.

- An alternatives analysis for any proposed action will be presented as part of ASAP or as an IM/IRA decision document.

- As per RFCA, contaminant plumes in RFETS groundwater which are stable and do not impact surface water above action levels will not require cleanup.

- All remedial actions will be consistent with the proposed end-state of RFETS.

4.4 POTENTIAL CLEANUP ACTIONS

Using available information, the following potential actions were conceptually developed for each major VOC contaminant plume in groundwater. As contaminated seeps are the most distal ends of these contaminated groundwater plumes, these will be managed through cleanup of groundwater sources, natural attenuation, and/or interception at or upgradient of seep locations in accordance with the action level framework and the ER ranking. Further analysis of alternatives for feasibility, cost effectiveness, and suitability must be performed before initiating any action. Figure 4-1 shows the conceptual location of the groundwater actions.

4.4.1 Potential Action for the 881 Hillside Drum Storage Area Plume

The final remedy proposed for OU 1 is to excavate those soils containing VOC concentrations greater than the Tier-I action levels. The volume of the source area requiring excavation is estimated at between 900 and 1,900 cubic yards of colluvium and weathered bedrock. Excavating the source will also remove much of the contaminated groundwater above Tier I action levels (Sampling and Analysis Report, 1996). After demonstrating that this proposed remedy has been effective, and that the source and much of the resulting contaminated groundwater have been removed, the French Drain and recovery well are expected to be removed from operation.

This remedial action will be protective of surface water quality, and should reduce or eliminate any potential long-term stress to environmental receptors of contaminants that may reach Woman Creek.

4.4.2 Potential Action for the Mound Site Plume

Cleanup of the Mound Site contaminated groundwater plume will consist of excavating the subsurface soil exceeding Tier-I action levels for soil cleanup criteria for VOCs. Contaminated materials in Trench T-1 will also be removed using the same criteria. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches South Walnut Creek. Interception of the contaminant plume will be accomplished by making improvements to the existing seep collection system at SW059. The contaminated water is expected to be treated by a passive system installed along the south bank of South Walnut Creek.

Containment and treatment of the contaminant plume in Mound Site groundwater will result in a reduction of risk to the environment posed by uncontrolled releases of contaminated groundwater to surface water.

4.4.3 Potential Action for the 903 Pad and Ryan's Pit Plume

The proposed action is to remove contaminant sources exceeding the Tier I soil action levels for VOCs in soil from the 903 Pad area. Removal of the subsurface soils in the Ryan's Pit area has

202

already been completed. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches Woman Creek. The contaminated water is expected to be treated by a nearby passive system.

4.4.4 Potential Action for the Carbon Tetrachloride Spill Plume

There are two potential actions identified for this groundwater contaminant plume: (1) source removal by using shallow recovery wells to remove as much of the free-phase carbon tetrachloride as possible, and (2) removal of the contaminated soils, adjacent tanks, and associated piping. At this time, the building infrastructure in the area is containing this plume. Monitoring must continue to ensure that contaminated groundwater does not impact surface water. After removal of the infrastructure, near surface capture of this plume may be required to minimize impacts to surface water. If required, the captured water will be treated at a nearby passive treatment plant. This area may be capped as part of the 10-Year Plan. The impact on groundwater must be determined to see if additional controls are necessary.

4.4.5 Potential Action for the East Trenches Plume

Source remediation for Trenches T-3 and T-4 was completed in 1996 to remove subsurface soils that exceed the applicable RFETS soil cleanup criteria for VOCs. This action removed the contaminant source of this contaminated groundwater plume. The remedial action proposed for the remaining contaminated groundwater plume is to install a near-surface plume capture system near the distal end of the plume, and to use passive technologies to treat the contaminated groundwater.

4.4.6 Potential Action for the IA Plume

This groundwater contaminant plume may not require action because source removal and D&D activities will remove contaminant sources, the source of water in the plume will be reduced over time as capping and/or regrading reduces infiltration, and water loss from the RFETS plumbing will be eliminated. Monitoring must continue to ensure that contaminated groundwater does not migrate, or create a threat to surface water. An upgradient groundwater barrier is not recommended as preliminary calculations indicate that only 15 percent of the present recharge (precipitation plus

203

groundwater influx) to the IA could be diverted by an upgradient barrier, preventing approximately 4 gallons per minute of groundwater flux from entering the IA.

4.4.7 Potential Actions for Additional Plumes

Present Landfill Plume

An interim remedial action has been installed at this location to collect the contaminated groundwater and leachate flowing from the landfill for treatment. This gravity-driven system consists of cement vaults for collecting the contaminated water. Treatment includes a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents. Contaminated water is treated to comply with established cleanup levels. This treatment should effectively mitigate the potential ecological risk from the contaminants of concern. The treatment system may change or be eliminated once the Present Landfill cap is installed, because groundwater migration may no longer be a concern.

Solar Ponds Nitrate Plume

Proposed remedial actions for the groundwater nitrate plume, if required, will be developed at a later date, based on final cleanup standards and site-specific hydrogeologic conditions. No source removal is planned for nitrate-containing media. However, a cap/cover is being considered, which would reduce the groundwater recharge and the flow through the nitrate-contaminated soils.

Recommendations from the Working Group, if approved by the Water Quality Control Commission (WQCC), will change the stream classification for nitrates from drinking water to agricultural. There is some possibility that this surface water will be used for irrigation. Measures are being implemented which will restrict use of this water for domestic use. If the drinking water classification is lifted, then the nitrate concentrations seen in the surface water as a result of the nitrate plume are acceptable for all of the remaining uses, and could be of benefit for irrigation.

PU&D Yard Plume

A limited field investigation will be completed in 1997 to determine the impact to surface water. This will be followed by a source removal the same year. The limited field investigation will determine whether groundwater remedial action(s) are required to protect surface water.

Other 881 Hillside Groundwater Contamination

No action is required to mitigate this plume as it is not impacting, or expected to impact surface water. Any point sources around the building are expected to be dealt with during building demolition.

Old Landfill Groundwater Contamination

The VOC contaminated groundwater associated with the Old Landfill is limited in extent, closely related to the small source area, and is not a threat to surface water. Therefore, this contaminated groundwater does not require any action.

Walnut Creek Drainage Groundwater Contamination

It is most likely that the contamination in this area has migrated from a source upgradient of the Present Landfill, potentially the PU&D Yard (see above). Contaminated groundwater in this area will be addressed as part of the remedy for the upgradient plume.

4.5 PLUME RANKING

Sources or contaminant plume above action levels that are determined to be candidates for remedial actions have been prioritized to determine the sequence in which remediation will occur. To accomplish this task, a methodology was developed by CDPHE, EPA, K-H, and RMRS staff to rank the known environmental risks at RFETS and is outlined in the "Environmental Restoration (ER) Ranking" (RMRS 1995).

205

The ER ranking is currently being updated to incorporate the new action levels. Sites are ranked using the following criteria: 1) concentrations of contaminants present in soil, subsurface soil, and groundwater; 2) impact to surface water; and 3) the potential for further release which quantifies the possibility that source material will continue to release contaminants into the environment. The resulting prioritized list is used to determine the general order in which to implement remedial actions.

This methodology incorporates a very conservative approach. As a result, IHSSs, areas and groundwater plumes where formal risk assessments have determined that there is no unacceptable risk may rank higher than expected on the prioritized list.

The Working Group recommended that the groundwater plumes be prioritized separately from the contaminant sources to allow the groundwater actions to be initiated separately from the source removal actions. The methodology for ranking the groundwater plumes follows:

1) **Score Ratio**: Analytical data for VOCs in groundwater since 1990 were compared to the proposed Tier II action levels, and a ratio of the analytical result to Tier II action level value was calculated. The maximum ratio for each analyte within the contaminant plume was tabulated, and a total score for each groundwater plume was calculated by summing the maximum ratios. The resulting summed values were then converted to a Score Ratio using Table 4-1.

2) **Impact to Surface Water**: A rating of 1 to 3 was assigned to each plume based on the evaluation of whether or not the groundwater contaminant plume was impacting surface water at Tier I action levels (a rating of 3), had the potential or was impacting surface water at Tier II levels (a rating of 2), or did not pose a threat to surface water at this time (a rating of 1).

3) **Potential for Further Release**: A rating of 1 to 3 is assigned based on an evaluation of whether or not there is a potential for contaminants to continue to migrate into groundwater (i.e., is an uncontained source present?). If there is probably free product present, a rating of

3 is assigned, if high concentrations of contaminant are present in soil, a rating of 2 is assigned and if there is probably no uncontained source present, a rating of 1 is assigned.

Table 4-1 Converstion Table for Scores

Summed Groundwater Ratios	*Score Ratio*
> 20,000	10
10,001 - 20,000	9
5,001 - 10,000	8
1,001 - 5,000	7
501 - 1,000	6
251 - 500	5
126 - 250	4
76 - 125	3
26 - 75	2
1 - 25	1

The ER Ranking was recalculated in September 1996 using the new action levels and standards, and including the groundwater contaminant plumes. Table 4-2 provides the rankings of the groundwater contaminant plumes.

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The following is an example showing how the three factors were used to generate the ranking for the 903 Pad groundwater contaminant plume. Concentrations of VOCs in groundwater in the 903 Pad and Ryan's Pit plume were identified and compared to the appropriate Tier II values. The maximum ratios for each contaminant that exceeded Tier II action levels were summed, which equaled a value of 603. Using Table 4-1, this value equated with a Ratio Score of 10.

Next, the impact to surface water was evaluated. Because the contaminants are believed to be impacting surface water near Tier II levels, the a factor of 2 was used. Finally, the potential for further release was believed to be high and a factor of 3 was assigned, based on the belief that there is free product underneath the 903 Pad that is still being released into the groundwater.

Multiplying the Ratio Score of 10, times the impact to a surface water impact factor of 2, times the factor for potential for further release of 3, generated a ranking score of 60.

but table 4-2 says the rank is 12~~0~~ ???

207

not defined in text

Table 4-2 Plume Ranking

Plume	*Priority Score*	*Ranking*	*Comments*
Mound	30	11	
903 Pad and Ryan's Pit	20	12	Ryan's Pit source removed ???
East Trenches	20	13	Sources removed and U??
Solar Ponds	20	17	Ranking due to nitrate concentrations
Present Landfill	18	19	Groundwater presently collected/treated
PU&D Yard	16	22	
881 Hillside Drum Storage Area	10	26	
Carbon Tetrachloride Spill	10	27	
IA	10	28	
Building 881 Area	9	32	Below Tier I action levels
Old Landfill	8	35	Below Tier I action levels

T-3 & T-4 Souces removed

Shouldn't these be reversed?
1. E. Trenches
2 903 Pad
3. Mound
based on: concentrations
mobility
impacts to SW ???

208

5.0 NEXT STEPS

Additional data must be collected and/or analyzed before implementing actions. Not all groundwater contaminant plumes and sources are characterized sufficiently to implement an action, and appropriate methodologies for collection and treatment must be identified. The ecological impacts of groundwater collection and treatment must be determined, as collection of the distal plume boundaries may irreparably damage wetlands and seeps.

Before implementation of any remedy, a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA) or PAM must be prepared, and an engineering design must be completed.

Based on the currently available information, following are the steps already completed towards groundwater remediation, and the proposed next steps:

- Soils in OU 1 881 Hillside Drum Storage Area (IHSS 119.1) that contain contaminant concentrations above action levels may be excavated, removing material above the Tier I Action Level. Because the source of groundwater contamination would be removed, the use of the French Drain system and recovery well may no longer be necessary. After monitoring demonstrates the effectiveness of the remedy, these will be removed from service.

  The seep near Woman Creek will be evaluated to determine whether it is related to the 881 Hillside Drum Storage Area, and if there is an impact to surface water above action levels.

- The source of the Mound plume is anticipated to be remediated as an accelerated action. Pre-remedial investigations were completed in 1996 to delineate the extent of the contaminant source for this plume. Further pre-remedial investigations to determine the extent of the distal end of the groundwater contaminant plume, and effective, passive treatment methodologies are expected to continue in the near future. Gravity-flow passive treatment systems will be the preferred option.

- The sources of the 903 Pad and Ryan's Pit plume are scheduled to be removed. The Ryan's Pit source has already been characterized and remediated. Pre-remedial investigations are proposed to determine the extent of the source. The distal ends of the groundwater contaminant plumes require better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred option.

- A pre-remedial investigation is proposed for the carbon tetrachloride spill plume (IHSS 118.1) to better define the source, and to evaluate remedial actions. A limited pump and treat system may be installed due to the large amount of free product present in a limited area. If required, after removal of the surrounding buildings and associated footing drain systems, a passive collection and treatment system may be installed to contain the dissolved phase of this plume. This system would be located along the post-building removal, downgradient flow path near the impacted drainage.

no contributions from the other trenches???

- The sources for the East Trenches plume have been removed. Accelerated actions were completed in 1996 to excavate Trenches T-3 and T-4, and materials above the Tier I action levels were removed. The distal end of this groundwater contaminant plume requires better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred options.

- The IA plume will continue to be monitored to ensure that there is no increase in migration, and that there is no impact to surface water quality.

- Groundwater treatment systems need to be investigated to determine the optimum treatment methodology.

- The unknown extent of the chlorinated solvent plumes associated with the PU&D yard (IHSS 170, 174a, and 174b) is a data gap. Because the nature of the southern boundary of these plumes is undetermined, the potential impact to surface water cannot be evaluated. A limited characterization investigation will be conducted in 1997 to determine the extent of the plume, and to determine the location, nature and size of the source material. Previous investigations suggest that the contaminant source(s) may be located immediately east of the known PU&D yard boundary. Source removal is expected to follow in 1997 if a contaminant source can be defined.

- Soil vegetative caps or covers may be used throughout RFETS where necessary to limit natural recharge caused by precipitation from leaching of contaminants in the unsaturated zone and into groundwater. This would greatly reduce the movement of groundwater through the IA, and thereby reduce the mobility of the contaminant plumes. Subsurface sources of groundwater contamination would be removed where practical. At the end of the D&D/remediation phase, the plant water supply and sanitary sewer will be shut off. This will eliminate a major source of groundwater recharge for the IA, and should greatly reduce the mobility contaminant of the IA and carbon tetrachloride spill plumes.

Further analysis is required to determine optional intercept locations, actual treatment methodologies, and cost-effective project planning and scheduling.

The ER Ranking scheduled to be completed in 1996 and the proposed ranking of groundwater plumes presented in Section 4.5 provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

6.0 REFERENCES

DOE, 1992a, *Final Groundwater Assessment Plan*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, February.

DOE, 1992b, *Final Historical Release Report for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, June.

DOE, 1993, *Final Groundwater Protection and Monitoring Program Plan for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, October.

DOE, 1994, *RCRA Report.*

DOE, 1995, *Intrinsic Remediation Monitoring Task 1 Evaluation Report,* U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, March.

EG&G, 1992, *OU 2 Domestic Water Supply Simulations*, (Internal Report), EG&G Rocky Flats, Golden, Colorado, September, 9p.

EG&G, 1994, Technical Memorandum Final Work Plan OU 7, Volumes 1-4, RF/ER-94-00044, September.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

EG&G, 1995c, *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site*, Volume III of the Sitewide Geosciences Characterization Study, EG&G Rocky Flats, Golden, Colorado, January.

EG&G, 1995d, *1994 Well Evaluation Report for the Rocky Flats Environmental Technology Site (Final),* EG&G Rocky Flats, Golden, Colorado, March.

EPA, 1992, *Chemical Enhancements to Pump-and-Treat Remediation*, U.S. Environmental Protection Agency EPA/540/S-92/001.

EPA, 1994, *Draft Soil Screening Guidance*, U.S. Environmental Protection Agency, EPA/540/R-94/101.

RMRS, 1995, *Environmental Restoration Ranking*, RMRS Rocky Flats, Golden, Colorado, September 27.

RMRS, 1996a, White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company, August 16, 1996.

To: Distribution
From: Annette Primrose
Date: September 17, 1996

Subject: Review of the Draft Groundwater Conceptual Plan

Attached is a copy of the Draft Groundwater Conceptual Plan for your review. This document was originally submitted in March 1996, and has been revised to reflect changes in RFCA, and to include more information about groundwater plumes.

The table of contents, references and figures have not been finalized and are currently being revised. These are provided for your information only. The appendices have not been included, as these are derived from other documents and cannot be changed. In addition, all references to figures in the Landfill plume discussion will be deleted to be consistent with the other, non-Tier I plumes.

I would appreciate a quick turn-around on this document if possible. Please return comments as soon as possible, preferably by close of business Thursday.

Thank you for your assistance.

Distribution:

Greg DiGregorio
John Hopkins
John Law
Tim Lovseth

ASAP was used as basis of ISB & 10 year plan, ASAP treatment, simple & effective or passive

- well done.
* Tie to required RFCA evaluation if > 100x MCL is this an evaluation? We cite ASAP extensively but are planning to 10 year plan/ISB. Perhaps J. Hopkins can recommend a solution.
- Great improvement in plumes discussion
* We promote passive systems for treatment but Dr. Hopkins has indicated small strippers ~~may~~ may be cost effective.
- Steve Singer should read this for impacts on monitoring program/technical input as well as potential reporting needs.

214

TABLE OF CONTENTS

215

FIGURES

TABLES

216

EXECUTIVE SUMMARY

The Groundwater Conceptual Plan provides a basis for cleanup and management of contaminated groundwater at the Rocky Flats Environmental Technology Site (RFETS) consistent with the Rocky Flats Cleanup Agreement (RFCA) Preamble, and the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils*. ~~The Groundwater Conceptual Plan describes the~~ redundant ~~management and cleanup of contaminated~~ groundwater ~~at RFETS~~. This plan was originally issued in March 1996, but has been revised to reflect the Final RFCA, and to include more groundwater plume data.

Addressing groundwater on a sitewide basis allows for effective coordination of groundwater activities, and provides consistency in addressing groundwater contamination. Because domestic use of groundwater at RFETS will be prevented through institutional controls, the goal is to manage or cleanup groundwater to protect surface water quality for all agreed-upon uses. In addition, the Groundwater Conceptual Plan identifies, describes, and ranks the principal groundwater contaminant plumes to provide a planning basis for funding, and implementation of groundwater actions.

The lateral extent and spread of contaminants in RFETS groundwater is limited by hydrogeologic conditions, therefore the contaminant plumes are relatively stable. In addition, groundwater discharges to surface water before leaving RFETS and there is a natural vertical barrier to downward migration of contaminated groundwater. Low-permeability claystones form a barrier at least 500-feet thick between contaminated groundwater at RFETS and the Laramie/Fox Hills aquifer.

Start talking GW plan + switch to RFCA w/o reference to RFCA.

The volatile organic compound (VOC) contaminant plumes in groundwater have the most potential to impact surface water, and are the primary focus of the Groundwater Conceptual Plan. RFCA or GWCP Contaminant plumes with other, inorganic, constituents were are? addressed where surface water is impacted above action levels. A two-tiered approach for action levels was developed for groundwater and soils to be protective of surface water uses as well as to be protective of the ecological resources. The Tier I action levels were developed to identify potential cleanup targets. For groundwater, these were defined as 100 x Federal Drinking Water Maximum Contaminant Level (MCL) for VOCs. Tier II action levels were developed to identify contaminated groundwater that may impact surface water and were defined on the basis of exceedances above the MCL for individual constituents.

217

Six groundwater contaminant plumes have been identified where contaminant concentrations exceed the Tier I action levels. These contaminant plumes are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Site Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) Industrial Area Plume. In addition, other groundwater plumes do not exceed the Tier I action levels, but may have the potential to impact surface water. These additional plumes include the Present Landfill, Solar Ponds and Property Utilization and Disposal (PU&D) Yard plumes.

Proposed cleanup actions consist of source removal or containment, with capture and treatment or management of the contaminated groundwater. Using available information, potential actions were conceptually developed for each major groundwater contaminant plume. Based on capture and treatment effectiveness, installation and operating costs, and plant infrastructure requirements, passive captive and treatment methods were the preferred conceptual actions. Before each cleanup action can begin, analyses must be done to select the specific cleanup alternative, and to perform engineering design. Additional data may be needed to select appropriate treatment systems and ensure the proper placement of cleanup systems.

The groundwater contaminant plumes were ranked based on the methodology previously developed to provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

1.0 INTRODUCTION

The Groundwater Conceptual Plan was originally developed as a joint effort between the Department of Energy, Rocky Flats Field Office (DOE/RFFO), Kaiser-Hill Company, L.L.C. (K-H), Rocky Mountain Remediation Services, L.L.C. (RMRS), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). This plan incorporates the final Rocky Flats Cleanup Agreement (RFCA) (July 19, 1996), and guidance from the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils Working Group ("the Working Group"). This Working Group was formed to:

- Provide a basis for future decision making,
- Define the common expectations of all parties, and
- Incorporate land- and water-use controls into site cleanup.

The Groundwater Conceptual Plan was originally issued in March 1996, and has been revised to incorporate changes in RFCA, and additional information on plumes.

1.1 ROCKY FLATS CLEANUP AGREEMENT AND ACCELERATED SITE ACTION PROJECT (ASAP)

Signatories to The RFCA are ~~was finalized between~~ DOE/RFFO, EPA, and CDPHE. Its purpose is to ensure the effective and efficient cleanup of RFETS. The RFCA Preamble mandates that environmental cleanup will be implemented through an integrated and streamlined regulatory approach. The RFCA preamble also defines the approximate areal extent of the five future conceptual land uses: (1) capped areas underlain by waste disposal cells or contaminated materials closed in-place, (2) an industrial-use area, (3) restricted open space, (4) restricted open space because of low levels of plutonium contamination in surface soils, and (5) unrestricted open space.

The RFCA Preamble states that the goal of soil and groundwater management and cleanup is the protection of surface water quality for the designated uses. Proposed actions will be designed to

protect ecological resources to protect the appropriate industrial or open space uses. Groundwater will not be used for any purposes at RFETS, except as related to cleanup activities.

ASAP was developed as a strategy to reduce risks and close RFETS. The strategy is being used to develop a comprehensive action plan implement the objectives stated in ~~of~~ the RFCA Preamble and to ensure that, after cleanup, surface water and groundwater leaving the site will be acceptable for any use.

This Groundwater Conceptual Plan was developed using the conceptual RFCA Preamble objectives [illegible] and the *Action Levels and Standards Framework for the Surface Water, Ground Water, and Soils.* It conceptually describes the management and cleanup of contaminated groundwater to protect surface water and ecological resources.

How does this plan relate to ASAP?

1.2 PURPOSE OF THE GROUNDWATER CONCEPTUAL PLAN AT RFETS

Groundwater at RFETS is present in the shallow, unconsolidated sediments and subcropping bedrock throughout the site. In the past, each Operable Unit (OU) investigated groundwater within its boundaries without addressing influences from upgradient sources. However, groundwater is not limited by OU or Individual Hazardous Substance Site (IHSS) boundaries. Several sources may contribute to a single groundwater plume, and groundwater plumes may cross several OUs and contribute to surface water contamination a great distance from the source location. Figure 1-1 shows the location of the principal areas discussed in the text.

The Groundwater Conceptual Plan addresses groundwater on a sitewide basis, in order to allow effective coordination of groundwater activities, and establishes a consistent approach to addressing groundwater contamination. While remediation of groundwater contaminant plumes must consider both the source and the associated groundwater plume, groundwater plume remediation can be performed independently of source remediation. Because there is no exposure pathway to humans from contaminated groundwater, the programmatic goals are to protect surface water and the environment, and limit potential contaminant migration (to the extent possible).

or practable?

The three specific goals of the Groundwater Conceptual Plan are to:

1) Identify and describe the principal contaminant plumes in groundwater;

2) Rank the contaminant plumes for the purpose of establishing the priority for cleanup actions, in accordance with the method outlined in the "Environmental Restoration Ranking" (RMRS 1995); and

3) Provide an initial planning basis for funding and implementation of groundwater cleanup.

tie to ASAP / 10 yr plan ??

To meet these goals, the Groundwater Conceptual Plan proposes cleanup and/or management of contaminated groundwater through source removal, source control, and/or treatment of dissolved-phase plumes. Contaminated seeps are also addressed, as these represent the distal ends of the contaminated groundwater plumes. The Groundwater Conceptual Plan also recommends evaluating whether some areas of contaminated groundwater may remain in place, given that the programmatic goals can be met without active intervention.

1.3 DOCUMENT ORGANIZATION

The conceptual plan for groundwater restoration is presented in five sections: (1) Section 1.0 provides an introduction, describes the goals and purpose of the groundwater strategy, and presents the organization of the report; (2) Section 2.0 provides a summary background on groundwater at RFETS; (3) Section 3.0 presents the action levels and standards developed by the Working Group and describes the groundwater monitoring requirements; (4) Section 4.0 describes the various groundwater contaminant plumes present at RFETS and provides an overview of the proposed cleanup actions that may be used; and (5) Section 5.0 summarizes the proposed next steps.

This document also contains three appendices: (1) Appendix A is a list of acronyms used in this text, (2) Appendix B contains Attachment 5 to RFCA, the *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils*, and (3) Appendix C contains the executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company, August 16, 1996

2.0 HYDROGEOLOGY AT RFETS

A basic understanding of the hydrogeologic setting is important for evaluating the nature and distribution of contaminated groundwater at RFETS. The current reference documents for describing the sitewide geologic, hydrogeologic and groundwater geochemical data at RFETS are the "Geologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995a), the "Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995b), and the "Groundwater Geochemistry Report" (EG&G 1995c). Much of the following discussion was derived from these reports. Unpublished plume maps from the 1995 Well Evaluation Project were modified to generate the plume configuration maps in this report.

Figure 2-1 illustrates the geologic setting of RFETS. Conceptually, the shallow groundwater at RFETS flows through two separate water-bearing layers, known as hydrostratigraphic units. These units are defined based on observed differences in hydrologic and geochemical characteristics for each flow system. These units are generally referred to as the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). A third hydrostratigraphic unit, a permeable, deep regional artesian aquifer known as the Laramie-Fox Hills aquifer, lies below the LHSU and is used extensively as a water supply in the ~~RFETS and~~ implies we use at RFETS greater Denver area. The RFETS hydrostratigraphic units are described in the greater detail in the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (EG&G 1995b).

The UHSU is the predominant water-bearing unit of concern at RFETS and is considered to be equivalent to the "uppermost aquifer" as defined by the Resource Conservation and Recovery Act (RCRA). It consists of unconsolidated, sandy and gravely materials mixed with clay (i.e., alluvium, colluvium, and artificial fill), as well as weathered bedrock claystones and sandstones which are hydraulically connected to the alluvium. The LHSU consists of unweathered claystone with some interbedded siltstones and sandstones. There is a significant difference in the ability of each unit to transmit groundwater. For example, the geometric mean hydraulic conductivity value of 2×10^{-4} centimeters per second (cm/sec) for the Rocky Flats Alluvium (UHSU) is about three orders of magnitude greater than that for unweathered LHSU Laramie claystones (geometric mean of 3×10^{-7} cm/sec). ? The hydraulic conductivities of LHSU materials are similar to that required for a landfill liner (EG&G 1995b). Wells completed in the UHSU and LHSU generally have poor water-yielding

223

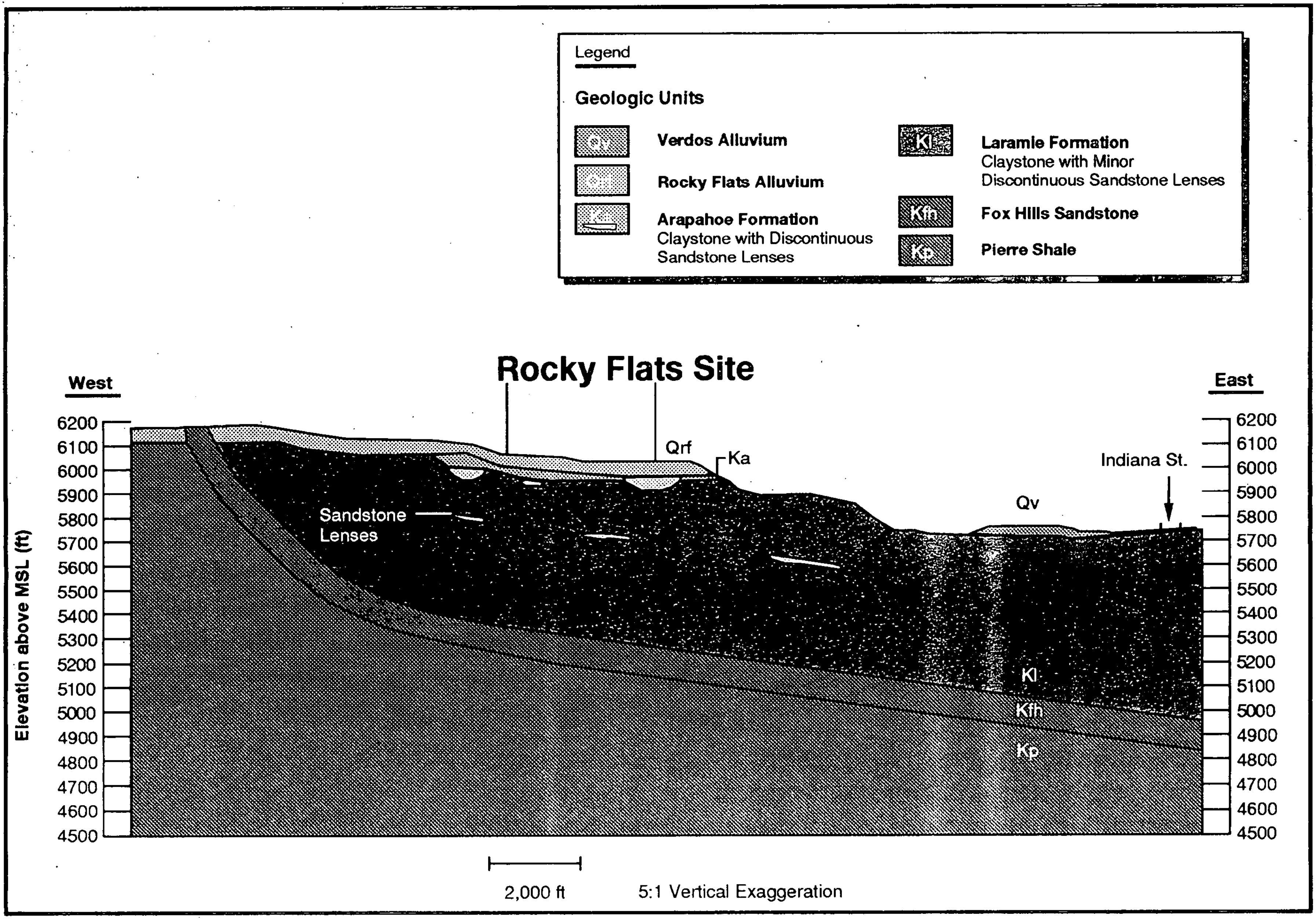


Figure 2-1 Generalized Geologic Cross-Section of the Rocky Flats Area

234

characteristics that prevent their development as viable water sources for residential use, although a few isolated UHSU well locations (i.e., bedrock sandstones in OU 2 (EG&G 1992) and valley-fill alluvium in Walnut Creek near Indiana Street (EG&G 1995d) have sustainable well yields that could support limited household use.

The spread of individual groundwater contaminant plumes at RFETS is limited by natural hydrogeologic conditions, including: the magnitude and distribution of hydraulic conductivities and hydraulic gradients; limited aquifer extent and interception of plume fronts by hydrologic boundaries (i.e., interception of groundwater contaminant plumes by drainages); and other physical controls, such as bedrock topography and the presence of discontinuously saturated areas, that constrain and moderate groundwater and contaminant movement.

For the most part, Groundwater ~~is estimated to~~ flows slowly at RFETS. For example, using Darcy's Law, the velocity of groundwater moving laterally through the Rocky Flats Alluvium in the East Trenches Area is estimated to be about 50 feet per year (assuming a hydraulic conductivity of 217.3 ft/yr, effective porosity of 0.1, and hydraulic gradient of 0.0213 ft/ft).

Because natural processes such as sorption and geochemical transformation reactions tend to attenuate the movement of organic contaminant plumes in groundwater, the velocity of contaminant movement is expected to be retarded relative to the groundwater flow velocity. Contaminants in the East Trenches Plume would then be expected to migrate at rates ranging from about 2.5 and 25 feet per year, based on a reasonable range of retardation factors and neglecting the effects of dispersion and diffusion. Other processes may further attenuate contaminant movement, such as diffusion of aqueous contaminants into clayey matrix materials. Therefore, in some cases, plume front movement appears to be imperceptibly slow. The apparent slow migration rate of some contaminant plumes at RFETS, although not fully understood, provides a higher level of confidence that temporary deferment of remedial actions at these plumes will not result in undue risks to the environment.

Groundwater in the surficial deposits of the UHSU generally flows to the east following bedrock and surface topography, and ultimately discharges to one of three stream drainages which are the main water pathways offsite. These drainages include Walnut and Woman Creeks, which receive

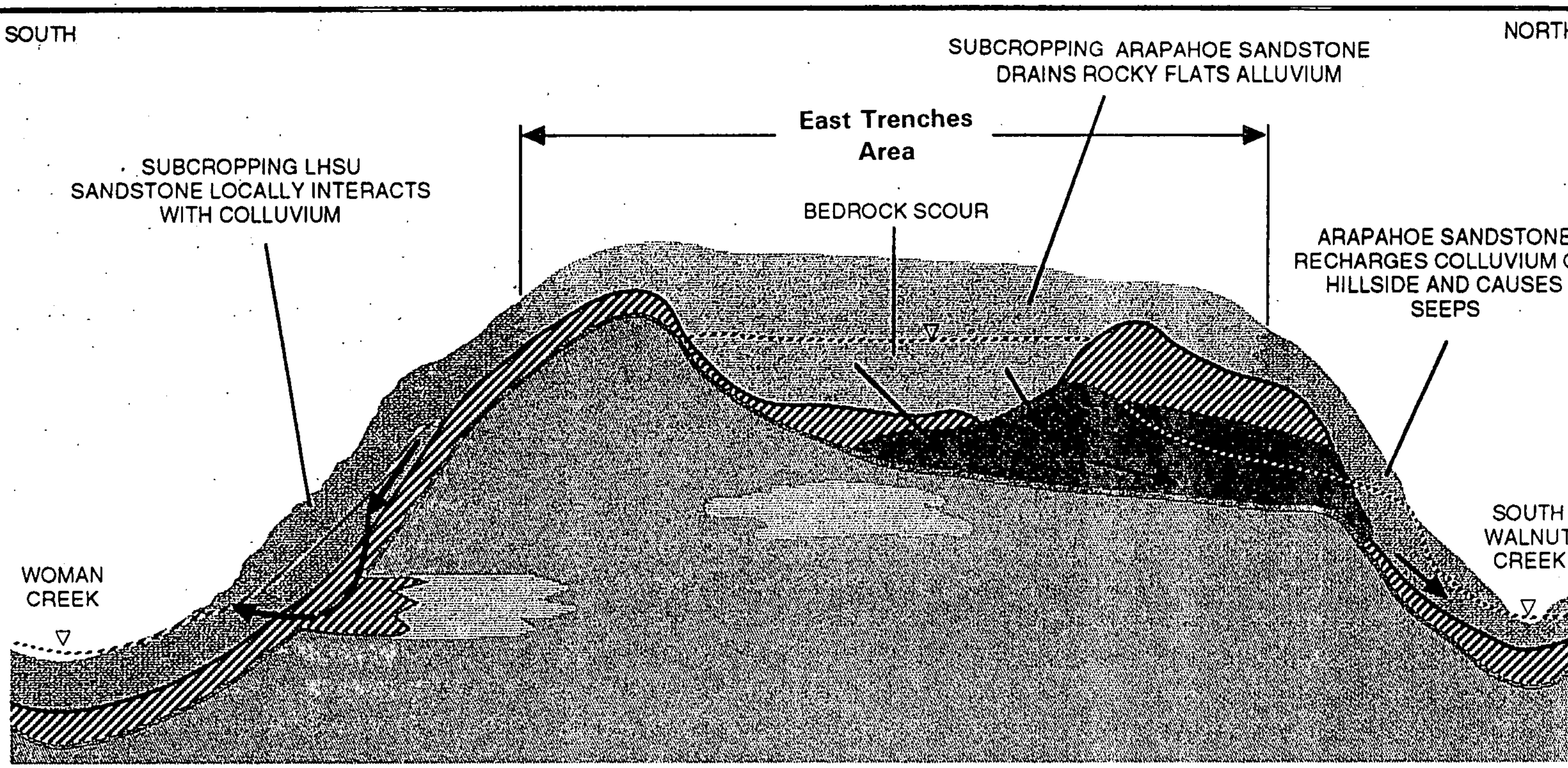
225

groundwater flow from the IA, and Rock Creek, which receives groundwater flow from areas essentially unimpacted by RFETS activities. Surface water flow from the IA is controlled by a series of impoundments in the Walnut and Woman Creek drainages. These impoundments also intercept groundwater flow associated with the valley-fill alluvium and promote intermingling of surface water with groundwater prior to release offsite. As a result, here is no known direct hydraulic connection between impacted groundwater at RFETS and offsite domestic wells.

In partially saturated areas, alluvial UHSU groundwater has been shown to preferentially flow along predepositional channels cut into the underlying bedrock surface (see Figure 2-2). These channels are known to occur in the IA, Solar Ponds, 881 Hillside, 903 Pad, and East Trenches Areas. Groundwater flow is often concentrated within these channels, and hillside contact seeps result where these channels are cut by erosional surfaces. These channels restrict plume spreading and movement. Other hydrogeologic controls for groundwater flow and contaminant transport are hydraulic gradient, distribution of subcropping sandstones and claystones, and topography. In the IA, features such as interceptor drain systems, buried utility lines, and building foundation drains control groundwater flow.

The lithologic and hydraulic characteristics of the LHSU cause it to act as a regional confining layer for the underlying Laramie-Fox Hills aquifer. The LHSU is a natural barrier to vertical groundwater flow and contaminant transport that effectively isolates impacted UHSU groundwater from deeper strata and the Laramie-Fox Hills aquifer (RMRS 1996a). At the IA the LHSU is estimated to measure at least 600 feet in thickness as shown in Figure 2-1 (modified from EG&G 1995a). By comparison, the average RCRA landfill is lined with only a few feet of similar material. These stratigraphic relationships, combined with an observed downward vertical hydraulic gradient, result in a LHSU groundwater flow regime that is predominantly vertically downward rather than horizontal. The available data from groundwater monitoring in the LHSU indicates that it is uncontaminated, with the exception of a few shallow LHSU wells with sporadic and, therefore suspect contaminant occurrences.

The available hydrogeologic and geochemical data suggest that fractures and faults are not significant conduits for downward vertical groundwater flow to deep aquifers (RMRS 1996a). Evidence of limited shallow hydraulic communication between UHSU and LHSU groundwater was found to exist in some wells, but these occurrences do not present a pattern consistent with known fault locations. Due to the thickness, lithology, and observed trend of decreasing hydraulic conductivity values with depth for the LHSU, it has been concluded that the LHSU has sufficient hydrologic integrity to provide long term protection of the Laramie-Fox Hills aquifer from shallow groundwater contamination (RMRS 1996). The executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN is presented in Appendix C and summarizes the hydrologic information used to reach the above conclusions.



EXPLANATION

(Qrf) ROCKY FLATS ALLUVIUM

(Qc) COLLUVIUM

UNWEATHERED CLAYSTONE/ SILTSTONE BEDROCK

WEATHERED BEDROCK

WEATHERED ARAPAHOE #1 SANDSTONE BEDROCK

LHSU UNWEATHERED SANDSTONE BEDROCK

GROUND WATER FLOW DIRECTION

CONCEPTUAL UHSU/LHSU BOUNDARY

WATER TABLE

Schematic Cross Section of Hydrostatigraphy at East Trenches Area

DRAFT OU2 PHASE II RFI/RI

April 1995

Figure 2-2

228

g95\ES\hydrodoc\hydrostat cross-sectn..cdw

3.0 ACTION LEVELS AND STANDARDS

?

The RFCA Preamble was used as the basis for the action levels and standards developed by the Action Level Framework Working Group. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and the Working Group considered all three media in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (July 19, 1996) is attached as Appendix B. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources. This framework for groundwater action levels is based on the conclusion that contaminated groundwater emerges as surface water before leaving RFETS.

229

3.2.1 Action Levels

The Working Group has defined the action levels, for Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated clean-ups, and Tier II action levels are protective of surface water quality. This approach, is described below.

Tier I

Tier I action levels were developed to identify potential cleanup targets in areas where VOC contamination of groundwater exceeds 100 times the MCL (100 x MCL). These action levels identify groundwater contaminant sources that present a higher potential risk to surface water quality that should potentially be addressed through an accelerated action. If Tier I action levels are exceeded, an evaluation is required to determine if remedial or management action is necessary to prevent the highly contaminated (i.e., contaminant concentrations exceeding 100 x MCLs) groundwater from reaching surface water (the evaluation process is described in Section 4.1). If action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

→ does this report constitute some phase of the evaluation? Should we be doing more?

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination.

230

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of Appendix B. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. Figure 3-1 shows the location of Tier II monitoring wells relative to the composite VOC plumes as described in Section 4.2. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	1386
10194	10692
1986	4087
10994	B206989

No longer Tier II but still in program

231

Groundwater Monitoring

Annette - Please have Steve Singer review & update to be consistent with IMP.

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan ~~a Groundwater Monitoring and Assessment Plan (GMAP)~~. The document will incorporate two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document will also describe recent changes to the groundwater monitoring network.

Check this date - I thought the Final was June in 1993

The IMP ~~GMAP~~ will list the wells with their appropriate regulatory driver, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The GMAP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, ~~unless subsequent changes~~ until change proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

230

Insert Figure 3-1

234 233

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water through groundwater transport of leached contaminants. The VOC contaminant plumes in subsurface soil and groundwater have the most potential to impact surface water. However, to provide cleanup guidance, action levels for inorganics that may be of concern at RFETS are currently under development in a manner consistent with that used for VOCs.

and actinides (plutonium, americium and uranium)

The soil VOC levels necessary to be protective of groundwater were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to determine the equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Using this approach, subsurface soil contaminant levels that would be protective of groundwater to 100 x MCLs were calculated and are presented in Appendix B.

- We probably need to provide a ¶ on actinide clean-up levels Rick Roberts would be a good resource for this.
- Perhaps we should have Chris Dayton & Laura Brooks review this section for accuracy prior to formal K-H review.

234

4.0 GROUNDWATER CONTAMINANT PLUMES AND REMEDIATION

4.1 IDENTIFICATION

The VOC contaminated groundwater plumes at RFETS have the most potential to impact surface water or to migrate offsite as the mobility of VOCs in groundwater far exceeds the mobility of metals and radionuclides. These plumes were defined on the basis of the exceedances of the Tier II action levels and are shown on Figure 3-1. Tier I action levels were compared against all groundwater data to locate areas of highly contaminated groundwater. These areas were plotted and are shown on Figure 4-1 along with proposed locations of the conceptual groundwater actions.

The probable sources of the VOC contaminated groundwater plumes were identified using the available data and process knowledge. The flow diagram (see figure 4-2) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should be targeted for remedial action.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed Tier I action levels. In addition, there are several plumes and areas of interest where contaminant concentrations do not exceed Tier I action levels, or are of very limited extent, but that are of interest due their potential to impact surface water above RFCA action levels, or due to their contaminant concentrations. The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard.

The 903 Pad and Ryan's Pit Plume, the Mound Plume, and the East Trenches Plume are part of a large composite plume on the east side of RFETS. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

350

INSERT FIGURE 4-1

236

4.2 DESCRIPTIONS OF CONTAMINATED GROUNDWATER PLUMES

The extent of contaminated groundwater plumes in RFETS groundwater is not rapidly changing (see Section 2.0). The contaminated groundwater plumes are described below with much of the data derived from the relevant RFI/RI reports, data summaries, and the Hydrologic Characterization Report (EG&G, 1995).

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as the hotspots removed in 1994 from this location had elevated plutonium levels.

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek. The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

Here, groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (OU 1 CMS/FS, 1995).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are ~~typically~~ usually the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

231

alluvium. The bedrock topography and ~~surficial deposit~~ thickness can be used to extrapolate where groundwater flow may occur (OU 1 Phase III RFI/RI, 1994).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the hot? or temperate? dry climate, slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3×10^{-3} to 2×10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2×10^{-6} m^2 /sec, approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992.

Groundwater data collected since the installation of the French Drain suggests that it is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (OU 1 Phase III RFI/RI, 1994).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location. These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (figure a). The eastern source area underlies one of the radiological hot spots removed in 1994. Both source areas could ~~easily~~ have been caused by leakage from individual drums (Identification and Delineation of Contaminant Source Areas for Excavation Design Purposes, IHSS 119.1, OU 1, April 1996).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Table A provides the range of concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996).

4.2.2 Mound Site Plume

The Mound Site was used for as a disposal site for approximately 1,405 drums from April 1954 to September 1958. Drums contained depleted uranium, beryllium, lathe coolant (about 70% hydraulic oil and 30% carbon tetrachloride) and tetrachloroethene. Plutonium contaminated waste was also stored at this location, but plutonium levels were below detection limits. After it was noted that some of the drums were leaking, the drums were removed along with visibly stained soil. In addition, radioactive soils were removed at later dates.

240

The OU2 Phase II RFI/RI investigation identified acetone, methylene chloride, tetrachloroethene, trichloroethene and cis-1,3,-dichloropropene in the subsurface soils (OU 2 Phase II RFI/RI Report, 1995). Characterization results indicate increasing concentrations of tetrachloroethene and trichloroethene to a depth of 20 feet and decreasing concentrations below that depth. The recent Mound investigation delineated the area of contamination as occurring near borehole 14295 and well 1987, comprising approximately 400 cubic yards. (Mound Site Field Report September 1996)

The Mound Site is located at the northern edge of the pediment where up to 12 feet of Rocky Flats Alluvium overlies fractured claystone of the Arapahoe Formation. The topography slopes steeply to the north away from the Mound Site towards the incised drainage of South Walnut Creek. The Arapahoe No. 1 Sandstone subcrops under the alluvium at the northwest corner of the Mound Site. This sandstone is truncated by the South Walnut Creek drainage and subcrops beneath the colluvium between the Mound Site and South Walnut Creek.

In the vicinity of the Mound Site, the Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. The hill slope below the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation is covered with unconsolidated colluvium primarily composed of clay, or silty and/or sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Depth to groundwater is approximately 12 feet at the Mound Site (within the weathered bedrock), and unconsolidated materials are generally dry much of the year. Saturated alluvium occurs in bedrock lows and paleoscours in the top of the bedrock. The groundwater flow appears to be primarily along the bedrock surface and is probably controlled by small channels incised into the bedrock surface. Groundwater flows to the north through the No. 1 Sandstone until it subcrops beneath the colluvium, indicated by a line of seeps along the slope towards South Walnut Creek. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration of precipitation or UHSU groundwater into the underlying unweathered claystone is limited.

Recharge occurs primarily through local infiltration of precipitation. The Central Avenue Ditch runs along the southern boundary of the Mound Site and probably also recharges the UHSU groundwater in this area. Discharge from the UHSU is mostly through seeps located where the water bearing units are truncated by the South Walnut Creek, and the evapotranspiration.

The groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound Site, to a point of discharge along the south bank of South Walnut Creek, upstream of the RFETS Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound Site area are suspected to be the source of the groundwater contamination. There is a possibility that Trench T-1 could contribute to this plume; however, dry wells between the Trench T-1 and the Mound Site indicate that the Mound Site is the primary source of the contaminated groundwater plume. There is apparently little to no contribution from VOC contamination at the 903 Pad as upgradient wells in both the No. 1 Sandstone and alluvium contain 0 to 2 ug/l total VOCs. (of mound ? somewhat confusing

Thirty-five VOCs were detected in the contaminated groundwater at the Mound Site. All except tetrachloroethene, trichloroethene, cis-1,2-Dichloroethene and vinyl chloride were below 100 ug/l. Tetrachloroethene was the predominant contaminant with the highest concentration of 13,000 ug/l found at the Mound Site. The maximum concentration of cis-1,2-DCE (214 ug/l) and trichloroethene (410 ug/l) was detected with the maximum tetrachloroethene value. Concentrations of these chemicals decrease towards South Walnut Creek. The maximum vinyl chloride concentration detected was 860 ug/l in a well along the South Walnut Creek drainage, indicating that this is a degradation product, not a primary constituent.

The contaminant plume is discharging through surface and subsurface seeps along the hillside, and along seeps on the south bank of South Walnut Creek. At seep SW059, groundwater containing low levels of VOCs with trace amounts of radionuclides discharges at a rate of 0.5 gallons per minute, or less. The seep is collected and treated at the Building 891 Combined Water Treatment Facility.

243

4.2.3 The 903 Pad and Ryan's Pit Plume

This contaminant plume has two closely spaced sources: (1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and (2) Ryan's Pit where VOCs were disposed of in a trench. The 903 Pad was characterized as part of the OU 2 Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (RFI/RI) (DOE 1995) and the following information was derived from that report.

The 903 Pad area was used to store drums that contained radioactively contaminated oils and volatile organic compounds (VOCs) from the summer of 1958 to January 1967. Approximately three fourths of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered by clean road base and an asphalt cap.

Ryan's Pit, previously referred to as Trench T-2, is located approximately 150 feet south of the 903 Pad. The dimensions of the pit are approximately 20 feet long, 10 feet wide, and five feet deep. The Pit was used as a waste disposal site from 1969 and 1971 for nonradioactive liquid chemical disposal. VOCs disposed at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only the liquids themselves were put in the pit; their containers were either reused or disposed of in other areas.

Materials placed in the Pit were supposedly screened for radionuclide activity prior to disposal. However, field investigations conducted in 1987 through 1993 do not substantiate this claim. The contaminated soils were removed from this site and treated during the 1995 removal action at Ryan's Pit. Free phase tetrachloroethene and motor fuel constituents were found during this removal action. Free phase DNAPLs are also suspected to exist underneath the 903 Pad as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's solubility).

The 903 Pad is located on the flat surface at the southern edge of the pediment. A south facing hillside slopes downward from the 903 Pad to the SID and Woman Creek. Ryan's Pit is located on the hillside about 200 feet from the southern edge of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The 903 Pad is paved with asphalt, and there is artificial fill present under the 903 Pad and over a large area to the south and east of the Pad. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds.

The Rocky Flats Alluvium is truncated by erosion and does not extend to the Ryan's Pit area. The Ryan's Pit area surficial deposits consist of reworked Rocky Flats Alluvium that has been transported down slope, along with other clay-rich colluvium deposits and fill material. Surficial deposits consist of colluvium between one and eight feet thick which is primarily clay, and silty or sandy clay. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. On the slope, there are numerous slump features with a large scarp face located between the 903 Pad and Ryan's Pit.

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at the extreme northwest corner of the 903 Pad. This sandstone is continuous with the Arapahoe No. 1 Sandstone at the Mound Site, where it is truncated by the South Walnut Creek drainage. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4}

cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7 x 10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thicknesses. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well-defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are fairly common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

A large bedrock low (paleoscour) extends from the 903 Pad east and passes directly south of the Northeast Trenches. This paleoscour is bounded by bedrock highs to the north and south. The paleoscour directs groundwater flow to the east till it is truncated by the South Walnut Creek drainage where alluvial groundwater discharges into the head of a well developed gully. Groundwater flow from the 903 Pad towards the SID and Woman Creek also occurs, either by overtopping of the lower, southern bedrock high, or through breaks in the bedrock high. During dry periods, the bedrock highs restrict alluvial groundwater flow to the south and north. During wet periods, when the alluvial groundwater levels are very high, flow may overtop these barriers, primarily to the south.

Groundwater flow in the colluvium follows north-south trending small paleochannels cut into the underlying bedrock claystone. One narrow paleochannel, approximately 150 to 300 feet wide, extends from the 903 Pad south through the Ryan's Pit area. The areas surrounding these paleochannels is unsaturated. The southern extent of groundwater flow is not well defined due to lack of well control.

Recharge is primarily from infiltration of precipitation along with some recharge from ditches and other surface water features. Wells located to the west of the 903 Pad are generally dry as alluvial groundwater inflow from the west is restricted by the claystone bedrock high just west of the 903

Pad. Unconsolidated materials within the medial portion of the paleoscour tend to be saturated, with the extent of saturation greatest during the Spring. Groundwater flow occurs through the No. 1 Sandstone until it subcrops beneath the colluvium. Discharge is primarily to seeps located where the water bearing units are truncated by the South Walnut Creek drainage. All UHSU groundwater is discharged to seeps or into the colluvium.

The 903 Pad and Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from these two source areas. This plume flows southward toward the SID and Woman Creek drainage. The lobe of contaminated groundwater which flows eastward from the 903 Pad is addressed as part of the East Trenches Plume.

Contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the alluvium and colluvium. Total VOC concentrations for the Arapahoe No. 1 Sandstone are approximately 2,500 ug/l adjacent to the west edge of the 903 Pad with concentrations at other locations less than 2 ug/l or non-detects. Fifty-seven VOCs were detected in UHSU groundwater for this plume. However, the primary contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene. The southern component of the contaminant plume derived from the 903 Pad contains total VOCs in the 5,000 ug/l range near the Pad, diminishing to 1,500 to 2,000 ug/l range upgradient of Ryan's Pit. Downgradient of Ryan's Pit, the total VOC concentration in groundwater ranges from 57,000 ug/l near the Pit to 5 ug/l near the distal end of the plume. The total VOC concentration in contaminated groundwater from the 903 Pad which does not also flow through the Ryan's Pit source is also estimated at 5 ug/l when it nears Woman Creek drainage.

The highest concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 ug/l) was detected immediately downgradient of Ryan's Pit and occurred with 1,1-dichloroethene at 380 ug/l. A well installed through the center of the 903 Pad contained concentrations of carbon tetrachloride in groundwater at 20,000 ug/l, chloroform at 39,000 ug/l and methylene chloride at 35,000 ug/l. A well installed though the northeast corner of the Pad detected tetrachloroethene at 14,000 ug/l. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although wells with VOC concentrations exceeding Tier I levels have been observed within the plume away from these sources.

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the South Interceptor Ditch and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit plume will reduce the risk to the environment posed by uncontrolled releases to surface water.

4.2.4 Carbon Tetrachloride Spill Plume

The Carbon Tetrachloride Spill (IHSS 118.1) is located due north of Building 776 and east of Building 730. While there are other IHSSs that overlap IHSS 118.1, (IHSSs 121-Tank 9, 121-Tank 10, 131, and 144[N]), the contamination in the area is primarily related to the carbon tetrachloride spills.

IHSS 118.1 is the site where an underground, 5,000-gallon, carbon tetrachloride steel storage tank and the associated piping were formerly located. The tank was installed prior to 1970, and probably began leaking shortly after installation. Numerous spills occurred before 1970, some between 100 to 200 gallons (HRR DOE 1992b). The tank ultimately failed in June 1981, releasing carbon tetrachloride into the containment structure. The carbon tetrachloride was pumped from the containment structure to the surrounding ground surface, and the tank was removed along with a limited amount of soil surrounding the tank. The surrounding concrete containment structure was probably removed at this time also, but this has not been verified.

The surrounding area has numerous underground and overhead utilities and structures. These include clay sanitary sewer lines, electrical lines, tunnels between buildings, process waste lines and process waste tanks. Immediately east and partially overlapping this site is a group of four process waste tanks oriented east-west, tank groups T-9 and T-10. T-9 consists of two 22,500 gallon underground concrete storage tanks. T-10 consists of two 4,500 gallon concrete underground tanks. Both sets of tanks were installed in 1955, but are no longer used as process waste tanks. T-9 ~~is~~ or T8? currently being utilized as plenum deluge catch tanks for Building 776. No releases from either set has been documented (OU 9 data summary 1995).

Due to past construction activities in this area, the material overlying the claystone bedrock is predominantly fill material, probably derived from the Rocky Flats Alluvium, along with some remaining undisturbed Rocky Flats Alluvium. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

The recent IA investigation found free product in the subsurface soil and groundwater related to IHSS 118.1. All four of the soil borings drilled around T-9 and T-10 intercepted free-phase carbon tetrachloride (OU 9 data summary 1995). When a water sample was collected at this location, the liquid separated into two distinct phases. Other VOCs may be present, but the high concentrations of carbon tetrachloride may mask their detection. The top of bedrock surface prior to construction of Building 771 sloped to the northeast. Excavation during construction of this building altered this surface as the claystone surface was found 10 feet or more below where it was expected during the recent field investigations. Excavation may have either increased the slope of the bedrock surface, or created a bedrock low closed by the building. The bedrock in this area is claystone which limits vertical migration of the carbon tetrachloride. As carbon tetrachloride sinks to the lowest possible depth, the bedrock surface, building footing drains, and subsurface structures probably control the extent of the free-product plume and much of the dissolved phase portion of the contaminated groundwater plume.

Groundwater flow in this area is to the northeast towards Buildings 771 and 774 where there are known footing drains. Buildings 701 and 730 are not believed to have subsurface structures. Monitoring wells in the area contain carbon tetrachloride in the groundwater which indicates that a dissolved plume is present in the groundwater. This contaminated groundwater plume may eventually reach the North Walnut Creek drainage, especially after removal of the surrounding buildings.

Carbon tetrachloride and trichloroethene concentrations have been detected in a downgradient well completed in the Arapahoe No. 1 Sandstone at the western edge of the Solar Ponds, due east of IHSS 118.1. Carbon tetrachloride concentrations range from approximately 1,000 to 21,000 ug/l and the trichloroethene concentrations range from 2,000 to 8,000 ug/l. The concentrations fluctuate greatly over time, but there is a general decreasing trend. The carbon tetrachloride spill is believed to be the source of this contamination and these contaminants indicate that there is some eastward movement of the dissolved phase of the plume. The decreasing trend over time may be a result of the VOCs in the vadose zone at the time of the spill, and settling to the bedrock surface, less in contact with groundwater over time. wording

flushing of upper soil layers?

The Solar Ponds area is in hydraulic connection with subcropping Arapahoe No. 1 Sandstone, which could act as a conduit for the dissolved phase carbon tetrachloride plume. However, this sandstone is not known to subcrop or outcrop in drainages, and it appears that the risk to surface water is minimal.

4.2.5 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area, primarily associated with the trenches on the north side of the East Access Road. These trenches are known as the Northeast Trenches and include Trenches T-3, T-4, T-10 and T-11. Upgradient wells indicate a component of the contaminated groundwater in this area is derived from the VOC contamination in the 903 Pad (see section 4.2.3). However, the VOC concentrations in groundwater increase over 100 times after the groundwater passes through Trenches T-3 (IHSS 110) and T-4 (IHSS 111.1), indicating a VOC source is present.

Marla/Shawn probably have actual measurement.

Trench T-3 is located approximately 300 feet north of the East Access Road and immediately west of Trench T-4. Trench T-3 is approximately 134 feet long, 20 feet wide and 10 feet deep (HRR). Trench T-4 is approximately 110 feet long, 15 feet wide, and 10 feet deep (Trenches and Mound Site Characterization Report, RF/ER-96-00044.UN, RMRS 1996). The trenches were reportedly used sometime between 1954 to 1968 for disposal of sanitary sewage sludge, potentially contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. The trenches are also known to contain DNAPLs, crushed drums, and other miscellaneous waste. Activities of the trench material are below the RFETS soil put-back levels. I believe some soils were > Tier II check w Marla

Trench T-3 and T-4 are located at the northern edge of the pediment where up to 18 feet of Rocky Flats Alluvium overlies fractured claystone and the No. 1 Sandstone of the Arapahoe Formation. Beyond the pediment boundary, the topography slopes steeply to the north towards South Walnut

253

Creek. Both the alluvium and the Arapahoe No. 1 Sandstone are truncated by the South Walnut Creek drainage.

The unconsolidated surficial deposits consist of the Rocky Flats Alluvium and artificial fill in the trenches and are generally dry. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. Thickness of the alluvium is approximately 18 feet at Trench T-4 and 16 feet at Trench T-3. Below the outcrop of the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation, the slope is covered with unconsolidated colluvium primarily composed of clay, or silty and sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Underlying the alluvium to the north of the trenches is the continuation of the claystone bedrock high from the 903 Pad area. The center of the associated paleoscour runs beneath Trenches T-11 and T-10 to the south of Trenches T-3 and T-4. This feature directs the surficial groundwater flow to the east, away from South Walnut Creek. However, the Arapahoe No. 1 Sandstone subcrops beneath the eastern portion of trench T-3 and most of Trench T-4. This fluvial sandstone is incised into the surrounding bedrock claystone and consists of sandstone, clayey sandstone, and silty sandstone. The channel of the Arapahoe Formation No. 1 Sandstone is approximately 40 feet thick and mostly saturated. Groundwater flow is generally unconfined, and flow within the channel is northward towards South Walnut Creek (EG&G 1995c). The sandstone subcrops beneath the colluvium between the trenches and South Walnut Creek at a spring and seep complex.

The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Arapahoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec and the geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Recharge of the Rocky Flats Alluvium is primarily through infiltration of precipitation, and upgradient flow from within the paleoscour. Recharge to the No. 1 Sandstone is from infiltration of precipitation through the surficial deposits, and some flow from upgradient. Discharge is primarily

254

to seeps and springs located where the water bearing units are truncated by South Walnut Creek, and by evapotranspiration.

Contaminated groundwater occurs in the alluvium and in the No. 1 Sandstone that is in hydraulic connection with the alluvium. While 27 VOCs were detected within the UHSU groundwater, the majority were detected at concentrations below 100 ug/l. The major contaminants are trichloroethene (maximum value of 94,000 ug/l), carbon tetrachloride (maximum value of 4,500 ug/l), and tetrachloroethene (maximum value of 1,000 ug/l). During the Soil Vapor Extraction Pilot Test Project, stratified water/NAPL samples were collected and analyzed from Trench T-3. Extremely high levels of VOCs were recorded, up to 37,000,000 ug/l for tetrachloroethene along with semivolatiles, petroleum compounds, and uranium-238 at concentrations up to 3,240 pCi/g (OU 2 Phase II RFI/RI, October 1995). In addition, during drilling activities, tetrachloroethene and trichloroethene were detected at concentrations of 12,000 and 1,000 ug/kg in Trench T-4.

The downgradient boundary of the contaminant plume is located at a spring and seep complex on the south bank of South Walnut Creek, above Ponds B-1 and B-2, where the No. 1 Sandstone subcrops. Concentrations of VOCs above 100 x MCLs have been detected by a recent sampling program conducted at the seep complex. There are potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

A lobe of this contaminant plume extends to the east of the East Trenches area along the paleoscour cut into the bedrock surface. However, contaminated groundwater has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored ensure that contaminated groundwater from this lobe does not impact surface water.

4.2.6 IA Plume

Several sources in the IA contribute trichloroethene, tetrachloroethene, and carbon tetrachloride to the contaminated groundwater plume in the IA. The plume is defined based on a small number of

255

wells, and is thought to be principally confined to the east central side of the plant. It is not clear whether it is a large coalesced plume, or discrete areas of contaminated groundwater closely associated with individual source areas. The contaminated groundwater plume is outside of the fenced portion of the protected area (PA) and extends downgradient towards the central portion of the IA. Primary contaminant sources are described below.

IHSSs 117.1 was used as a general storage yard from before 1959 to the early 1970s and is located northeast of Building 551 (DOE, 1992b). The IA field investigations found elevated levels of tetrachloroethene (2,200 ug/l) during the soil gas survey, with less than 20 ug/l concentrations of trichloroethene and carbon tetrachloride and cis-1,2-dichloroethene. Elevated benzene, toluene, ethylbenzene and xylene (BTEX) levels are present in the southwest edge of the IHSS (OU 13 data summary).

IHSS 117.2, located east of Building 551, was used as a chemical storage site from prior to 1971 until approximately 1988. This site was used to store acids, oils, soaps, solvents, and beryllium scrap metal. Minor leaks and spills occurred. (HRR) The IA field investigations have determined the presence of elevated levels of 1,1-dichlorethene (2,700 ug/l) along with concentrations above 100 ug/l for vinyl chloride, cis-1,2 dichloroethene, trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Elevated concentrations of BTEX are also present (OU 13 data summary).

There have been numerous carbon tetrachloride spills within Building 776, and under building contamination is suspected. This building may be the source of downgradient low level concentrations of carbon tetrachloride in groundwater. I thought it was outside the PA?

The IHSS 157.1 is adjacent to the Building 442 Laundry. Very low level concentrations (below 5 ug/l) of tetrachloroethene (PCE) were detected at this location (OU13 data summary).

IHSS 158 is an area where waste boxes were staged and loaded onto rail cars. This area is considered a radioactive site, and is located north of Building 551. Soil gas surveys found concentrations above 100 ug/l for vinyl chloride, toluene, and BTEX at this location (OU13 data summary).

256

IHSS 160 is a parking lot on the west side of Building 444. Drummed and boxed waste were stored at this location prior to paving, and leaked (HRR). The soil gas survey detected tetrachloroethene at 99 ug/l at this location. Concentrations less than 10 ug/l each of toluene, acetone, and benzene are also present (OU 14 Data Summary 1995).

IHSS 171 is a training area for fire department personnel. In the past, diesel, gasoline and possibly waste solvents were ignited for fire fighting training purposes. The area is currently in use, and a metal tree is used for burning propane for training. Large volumes of water are used during training which may tend~~s~~ to accelerate migration of any contaminant plume. As expected, large concentrations of BTEX are present in the subsurface soils. Soil gas samples do not indicate high concentrations of VOCs. However, during drilling of a geoprobe hole in this IHSS, the rod came up coated with a brown liquid. Unfortunately, a sample could not be collected for analysis. It is possible that free product VOC does exist at this location (OU 13 data summary).

The hydrogeology of the IA has not been as extensively studied as other areas at RFETS. The Hydrogeologic Characterization Report (EG&G 1995) was the primary source for the following hydrogeologic information. The IA is located on a pediment capped by the Rocky Flats Alluvium. The pediment has been eroded at the sides to expose the underlying claystone of the Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. Fill material is abundant and usually consists of reworked Rocky Flats Alluvium. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

Groundwater occurs under unconfined conditions and flow is generally controlled by the topography of the underlying bedrock surface. Groundwater flow direction in the IA is generally eastward, with groundwater in the northern sections flowing to the northeast. Several building footing drain systems locally impact groundwater flow. Small bedrock channels are known to occur which direct the groundwater flow.

The IA groundwater plume is greatly influenced by the RFETS infrastructure. Groundwater recharge in the IA is from upgradient flow, infiltration of precipitation and substantial water losses from sewers and water-supply pipelines. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

I believe G. Chadwick also says these may create localized areas of high recharge in adjacent areas.

The saturated thickness in the IA is typically 5 feet or less, with the greatest saturated thicknesses in the western part of the IA, decreasing to less than 5 feet in the eastern half of the IA. There are many unsaturated zones, particularly in the eastern half of the IA. These unsaturated areas are controlled by the bedrock, with bedrock highs generally dry. The decrease in saturated thickness in the eastern half of the IA may be caused by impermeable areas, such as parking lots and buildings, which greatly limit infiltration. Approximately 190 of 438 acres within the IA are covered by impermeable material. As a result, a greater amount of storm water runoff is channeled to permeable areas and may account for the large variations in saturated thickness. & recharge

Discharge from the IA is probably primarily to building footing drains, engineered structures such as the OU 1 French Drain and the Solar Ponds Interceptor Trench System, and potentially to seeps at the boundary of the IA. Both the Interceptor Trench and OU 1 French Drain have removed sufficient water from the surficial deposits to cause these to be locally unsaturated. Infiltration of groundwater into the underlying bedrock is generally limited due to the low hydraulic conductivity of the unweathered bedrock.

The IA groundwater contaminant plume extent is also controlled by interception of the plume by building footing drains and by the increased permeability and hydraulic conductivity through buried utility corridors. Full understanding of the migration of this plume depends on knowing how the various buildings, utility corridors, and sources interact. Unfortunately, there is insufficient knowledge of these factors to completely determine the configuration of this plume.

Figure X shows the average concentrations of VOC contaminants in the groundwater wells, and the probable contaminant sources. Treatment of contaminated groundwater within the IA does not appear to be necessary to protect surface water, because of the limited potential for migration. However, ongoing monitoring and evaluation of the groundwater will continue, to detect any possible movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand, migrate significantly or become a threat to surface water. Actions such as removal of buildings, removal of subsurface structures, and placing impermeable caps over areas must be examined to determine whether these will increase the movement of the contaminated groundwater plume. Controls may be required if increased groundwater contaminant plume movement results from these actions.

4.2.7 Additional Plumes and Areas of Contaminated Groundwater

There are several areas where there are sporadic occurrences of VOC contaminated groundwater, or where there are contaminant plumes with VOC concentrations less than 100 x MCLs. Contaminant plumes in the Present Landfill and Solar Ponds groundwater do not contain VOC concentrations greater than 100 x MCLs. However, these plumes are of interest because they are associated with RCRA units. In addition, a widespread but diffuse VOC plume is located near the PU&D Yard west of the Present Landfill. The setting and status of many of these plumes and occurrences are discussed below.

Present Landfill Plume

Operation of the Present Landfill (IHSS 114) for disposal of nonradioactive solid waste began in 1968 and will continue until the new landfill opens, or another method of waste disposal is available. The landfill covers an area of approximately 27 acres. The total volume of landfill material is approximately 415,000 cubic yards and consists of approximately 291,000 cubic yards of waste and 124,000 cubic yards of ~~daily~~ soil cover. what's that

Elevated tritium and strontium concentrations were detected in leachate draining from the landfill in 1973. To control the migration of contaminants, interim response actions were taken. Interim response activities included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill (West Landfill Pond and East Landfill Pond), a subsurface intercept system for diverting groundwater around the landfill and a subsurface leachate collection system. Between 1977 and 1981, the leachate collection and groundwater intercept system was buried beneath waste during landfill expansion. The lateral expansion of waste placement resulted in waste being located beyond the extent of the subsurface drains to the north and south. In 1982, two soil bentonite slurry walls were constructed to prevent groundwater migration into the expanded landfill area.

359

Leachate is a product of natural biodegradation, infiltration, precipitation, and migration of groundwater through waste. Approximately 5,756,000 gallons of leachate are present in landfill debris within the intercept system and above the unweathered claystone bedrock which is considered the underlying confining unit. The saturated thickness of surficial materials is greatest near the center of the landfill which suggests that recharge may be occurring by groundwater flow under or through the north groundwater intercept system (figure 4.2.7-1). Groundwater inflow may be occurring where the groundwater intercept system is not keyed into bedrock. Although an area of the south slurry wall is also not keyed into bedrock, well data indicates that it is effective in diverting groundwater.

During the Phase I RI/RFI investigation, 38 discrete groundwater samples were taken. In addition, 1990-1993 monitoring well data from 52 wells were used as the basis for determination of preliminary contaminants of concern. Groundwater in the UHSU at OU 7 contained metals, radionuclides, organic constituents and nitrates at concentrations higher than background (EG&G 1994).

The highest concentration of chlorinated hydrocarbons occurred in groundwater upgradient of the landfill. VOC contamination upgradient is composed entirely of chlorinated hydrocarbons. In contrast, average BTEX concentrations were highest in leachate collected from within the landfill. The BTEX compounds were not detected in upgradient groundwater. Different types of VOC contamination are presented within the landfill and upgradient (southwest) of the landfill, suggesting that a distinct source of VOC contamination is present upgradient of the landfill.

Two separate groundwater plumes exist in the vicinity of OU 7. The plume from the landfill source is located west of the landfill and is migrating down the No Name Gulch drainage. A second plume from an unknown source upgradient of the landfill is located in the groundwater south of the current landfill. The second plume is diverted around the southern slurry wall and then possibly migrates to the No Name Gulch drainage and/or Walnut Creek. A groundwater divide is located approximately 500 feet south of the southern slurry wall. Antimony, iron, manganese, tritium, uranium-238, chloromethane, ethylbenzene, and vinyl chloride concentrations in the groundwater exceed the Groundwater Tier II Action Levels. Because of the proximity to No Name Gulch, monitoring and further evaluation is required.

2660

Solar Ponds Nitrate Plume

The Solar Evaporation Ponds (SEPs) consists of five surface water impoundments. From 1953 to 1986, these were used to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. The materials placed into the SEPs included radioactively contaminated aluminum scrap metal, alcohol wash solutions, drums of waste radiography solutions, leachate from the Present Landfill, treated sanitary effluent, groundwater intercepted from the Interceptor Trench System (ITS), salt water solutions, wash water from the decontamination of production personnel, cyanide wastes, acid wastes and miscellaneous other compounds (OU 4 Proposed IM/IRA-EA Decision Document, February 10, 1995). Removal of pond sludge began in June 1985 and was completed for all SEPs by January 1995.

The SEPs are on the eastern boundary of the pediment capped by the Rocky Flats Alluvium. Streams have eroded the pediment to the north and south with topographic relief of 50 to 100 feet. Much of the surficial deposits have been disturbed by construction of the SEPs, the ITS, nearby buildings and other infrastructure, however, borehole logs suggest that undisturbed Rocky Flats Alluvium often occurs below the disturbed ground.

Thickness of the unconsolidated material ranges from 0 to 25 feet, and averages about 10 feet. The Rocky Flats Alluvium overlies over the erosional bedrock surface and consist of poorly to moderately sorted gravel, sand, silt and clay with boulder to pebble size clasts derived from the nearby Front Range. Artificial fill was used as for road grade fill, berm construction, recontouring around engineered structures, and to fill in lows for the surface impoundments. Fill consisted of reworked Rocky Flats Alluvium with imported offsite materials including crushed rock, plus sandy clay and gravel with fragments of concrete rubble. The Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and fill materials. Claystone is the predominant subcropping lithology, but the No. 1 Sandstone subcrops in the vicinity of South Walnut Creek.

The shallow, unconfined groundwater occurs in unconsolidated surficial material and fractures in the underlying bedrock and the potentiometric surface generally mimics the surface topography. General flow direction is to the northeast under the SEPs. A bedrock high trending east west under the SEPs diverts the northern flow to the north-northeast towards North Walnut Creek, and the

261

southern flow to the east-southeast towards South Walnut Creek. Unsaturated areas are present over a large part of the area, in part due to the ITS. However, unsaturated areas to the south and east are not impacted by the ITS. The saturated thickness varies from 0 to 5 feet over most of the area, and is thinner along topographic highs, or on slopes where there are thin alluvium or colluvium deposits. Along North and South Walnut Creek, the saturated interval can be as much as 10 feet thick.

Hydraulic conductivity for the Rocky Flats Alluvium in this area is around 10^{-5} cm/sec. No data were given for the fill material. The hydraulic conductivities for the subcropping bedrock claystone ranges from 10^{-7} to 10^{-9} cm/sec. The hydraulic conductivities for the subcropping bedrock sandstone ranges from 10^{-5} to 10^{-6} cm/sec (OU 4 Solar Evaporation Ponds Phase II Ground Water Investigation Final Field Program Report DOE February 1996).

do we need a figure to demonstrate?

There is a large UHSU nitrate plume that extends north and east from the Solar Ponds to the North Walnut Creek drainage above Pond A-1. A lobe of this nitrate plume extends to the southwest for a short distance. While the primary nitrate source has been removed for several years, this contaminant plume still contains nitrates at concentrations above 100 x MCLs. However, nitrate concentrations within the plume are decreasing with time. The Interceptor Trench System (ITS) was installed to intercept contaminants and capture the nitrate plume and was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gallons of water per year, but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE 1994).

VOC concentrations are present in the groundwater at the western edge of the Solar Ponds Area. These are most likely related to the carbon tetrachloride spill from IHSS 118.1 discussed earlier. Carbon tetrachloride is present at well P210189, completed in the 4 feet of silty sandstone believed to be the Arapahoe No. 1 Sandstone, at concentrations of 4,700 ug/l, tetrachloroethene at 1981 ug/l and trichloroethene at 2,200 ug/l. The extent of the contamination in the sandstone is unknown due to lack of well control. However, the other wells completed in this sandstone in the Solar Ponds area do not contain VOC contaminated groundwater. This sandstone does not appear to subcrop in the North Walnut drainage, and therefore does not provide a pathway to surface water. Uranium is also found in the Solar Ponds contaminated groundwater plume.

should we investigate?

262

PU&D Yard Plume

The PU&D Yard has been used since 1974 to store drums, cargo boxes and dumpsters. The PU&D Yard is located northwest of the industrial area in an area approximately 225 feet by 830 feet. Materials known to have been stored there include spent batteries, metal shavings coated with lathe coolant, and drums of spent solvents such as paint thinners and waste oils. Drummed hazardous material was also transferred in this area. Contamination exists from historical spills associated with past hazardous material transfer operations and storage at the site. Releases of battery acids and leaks from dumpsters and drums of spent solvents and waste oils have been reported.

The PU&D storage yard is underlain by the Rocky Flats alluvium which is approximately 25-30 feet thick in the vicinity. The alluvium is underlain by Arapahoe Formation claystone. Groundwater in this area flows to the east through the UHSU materials mimicking the surface topography.

Recent soil gas investigations have verified the presence of volatile organic compounds in the vadose zone, concentrated just outside the east and northern boundary of the PU&D storage yard. Organics, metals, and radionuclides have also been detected in surface soils (OU 10 data summary). However, subsurface investigations of the soil and groundwater have not been conducted.

An area of poorly defined, contaminated groundwater, with VOC concentrations slightly above the MCLs, is located downgradient of the PU&D Yard, and upgradient and to the south of the Present Landfill. Further investigation is required to identify the source or determine whether there is an impact to surface water quality.

Other 881 Hillside Groundwater Contamination

There are several one-time detects of VOCs in groundwater along the 881 Hillside. These do not seem to be related to a source, and may be more related to the problems of detecting very low levels of VOCs. In addition, there are two areas where contaminated groundwater has been identified, but where no action is required. Immediately adjacent to Building 881, there are sporadic detects of low

263

concentrations of chlorinated solvents in groundwater. This suggests that several, small point sources may exist in this area related to building operations.

The UHSU monitoring wells within the IHSS 119.2 drum storage area are dry or do not detect VOCs. However, there are infrequent detects of VOCs in groundwater sampled from two wells located within the drainage downgradient from IHSS 119.2. The source of these sporadic VOC detections may be the volatile plume derived from the 903 Pad.

In addition to the VOC contamination, the 881 Hillside groundwater contains selenium and vanadium at above background levels. Neither of these elements is a documented RFETS waste, nor requires remedial action to protect surface water.

Old Landfill Groundwater Contamination

The Old Landfill was in operation from 1952 to 1968 and was used to dispose of around 2 million cubic feet of miscellaneous RFETS waste. Accurate and verifiable records of the material placed into this landfill are not available, but all of the waste material was considered non-hazardous at the time. However, paint, solvents, paint thinners, oil, pesticides, and cleaning agents were placed in the landfill as these were not considered hazardous in 1968. The landfill also received some beryllium, depleted uranium, and used graphite. The Old Landfill does not have a liner, but the underlying unweathered claystone has a permeability of 10^{-5} to 10^{-7} cm/sec. The landfill was closed with a soil cover sometime after 1968 and prior to 1980 (OU5 Phase I RFI/RI Report, April 1996).

Groundwater occurs in the surficial deposits, primarily in the landfill material and alluvium. A large number of groundwater samples were collected during the OU5 RFI/RI investigation from wells, hydropunch samples from boreholes, and one-time samples from well points. The groundwater COCs identified by the OU 5 risk assessment for the Old Landfill are barium, manganese and radium, however, these do not correlate well with the waste disposed at this site. There are two small areas of VOC contaminated groundwater in the Old Landfill area. One area is associated with subsurface soil gas anomalies, and the other area is upgradient of the Old Landfill, probably related to the IA plume (section 4.2.6).

The OU5 RFI/RI soil gas investigation (DOE 1996) located two, small, subsurface soil anomalies at the Old Landfill. One area is approximately 50 feet by 50 feet with trichloroethene and 1,1,1-trichloroethene, and the other is about 64 feet by 64 feet with tetrachloroethene and trichloroethene. Trichloroethene (maximum concentration of 19 ug/l) is sporadically detected in groundwater at one of the wells associated with the larger anomaly. There are no VOCs in groundwater associated with the other anomaly.

One well upgradient of the Old Landfill (P416789) has had three historical detects of TCE. This well is probably detecting contaminated groundwater from the Industrial Area Plume. Seep samples from a location immediately downgradient of this well also contained trace amounts of VOCs.

Walnut Creek Drainage Groundwater Contamination

There are several wells in the area of the OU 6 trenches (IHSSs 166.1, 166.2 and 166.3) where low-level VOC and metal groundwater contamination is detected. Neither the subsurface soil samples taken from the OU 6 trench area nor the wells within the nearby Present Landfill contain the same contaminants found in the groundwater, and the OU 6 wells are located outside of the Present Landfill slurry wall. However, wells upgradient of the Present Landfill and outside of the slurry wall do exhibit similar contaminants and concentrations (see PU&D Yard plume above) (OU 6 RFI/RI Report, February 1996 and EG&G, 1994).

There several theories for the occurrence of these low levels of VOCs and metals (OU 6 RFI/RI):

- The trenches (IHSSs 166.1 to 166.3) may be the source of contamination and the field investigation did not detect these sources,
- The Present Landfill is the source, and the southern intercept wall is inadequate,
- Wastes may have been emplaced beyond the southern slurry wall, or
- Contamination is derived from a source upgradient of the Present Landfill, potentially the PU&D yard.

It is most likely that the contamination has migrated from a source upgradient of the Present Landfill.

265

4.3 CLEANUP ALTERNATIVES

The goal of this Groundwater Conceptual Plan is to manage and/or cleanup groundwater in order to be protective of surface water quality. The proposed cleanup of contaminated groundwater involves source removal or source containment, with treatment or management of the contaminated groundwater, to achieve this goal. Conceptual remedies for each major contaminant plume were developed by assessing the available technologies, and proposing a cost-effective, readily available technology.

Both active and passive remedial actions were initially considered. Active treatment actions such as pump-and-treat methods are well-known and accepted, but typically have high operation and maintenance costs, can have a negative impact on wetlands, may consume groundwater, have limited application in clayey aquifers, and are relatively inefficient for DNAPL source removal. Passive treatment actions include passive collection of groundwater with *ex situ* or *in situ* treatment. These systems may have higher initial capital costs, but have lower operation and maintenance costs, low energy consumption, no water consumption, and reduced equipment requirements. Passive treatment will collect DNAPL contaminated groundwater, but also will not remove the source.

The pump-and-treat methodology is commonly used and accepted. EPA has identified the pump-and-treat methodology as one of the most frequently used methods for groundwater remediation, but recognizes that pump-and-treat methods may require decades of potentially expensive operations to achieve cleanup levels (EPA 1992). A preliminary analysis was performed on the potential effectiveness of pump-and-treat methods at RFETS. The analysis concluded that pump-and-treat methods would not be an effective treatment for most contaminant plumes at RFETS, based on the following:

- Neither the UHSU nor the LHSU are capable of producing significant quantities of water, because both have a relatively large clay content.
- Aquifer tests conducted at RFETS show that, for the most part, aquifer yields are low, ranging from 0.000006 gpm to 12 gpm, with an average of 0.3 gpm (EG&G 1995b).

- Factors limiting water production within the UHSU include relatively thin saturated thicknesses and the presence of broad areas that become unsaturated during the fall and early winter (EG&G 1995b).

- Surficial deposits at RFETS have hydraulic conductivities in the 10^{-3} to 10^{-4} cm/sec range, whereas weathered and unweathered claystone bedrock have hydraulic conductivities in the 10^{-7} cm/sec range. The valley-fill alluvium is the most permeable unit, but no contaminant sources are known to be present in this unit.

- Due to the relatively low permeability of the geologic units at RFETS, cones of depression induced by groundwater removal would typically have very steep gradients, requiring a large number of closely spaced wells to effectively implement pump-and-treat remediation.

- Upgradient extraction of groundwater may adversely impact the present widespread distribution of seeps and springs (EG&G 1995b).

- Most of the contaminant plumes in RFETS groundwater have suspected sources consisting of DNAPLs, which are difficult to remediate by using pump-and-treat or passive methods because:

  - DNAPLs have low dissolution rates in water and are denser than water, and therefore tend to sink to the bottom of the unit.
  - The high clay content tends to adsorb DNAPLs, making these difficult or impossible to remove.
  - Pump-and-treat remediation leaves residual DNAPLs, which will continue to act as a source, further releasing dissolved contaminants to the groundwater system.

It may be possible to implement pump-and-treat methods for groundwater near the East Trenches, where the No. 1 Sandstone is contaminated. However, a large number of closely spaced wells would be required to effectively pump-and-treat groundwater due to the low conductivities and the resulting steep cones of depression. DNAPL contamination could easily remain after treatment. For these reasons, and the associated higher costs for this methodology, the pump-and-treat option was not considered as the proposed remediation treatment in this area.

When properly placed, a passive collection system near the distal ends of plumes will effectively capture the DNAPL-contaminated groundwater, but a contaminated plume would be left upgradient to naturally attenuate (DOE 1995). The contaminants in the plume will degrade with time, and upgradient water will flush the source material toward the collection system.

All proposed actions discussed below were selected to be effective, inexpensive to install and operate, and require minimal plant infrastructure support. For these and the preceding reasons, passive treatment actions are the preferred proposed remediation.

Passive systems proposed for treatment of contaminant plumes in RFETS groundwater include:

- *In situ* passive collection and treatment system such as a funnel and gate, where contaminated groundwater is funneled into a reactive barrier by selective placement of relatively impermeable barriers. Treated water is released back into the groundwater downgradient of the barrier. Such treatment systems have been used effectively at other sites.

- Collection of contaminated water from springs, seeps, and/or shallow drains, then pumping the collected water to an existing treatment facility (Building 891 Combined Water Treatment Facility), and discharging the treated water to the surface water system.

- Contaminated water collection from springs, seeps, and/or shallow drains, then using gravity to feed the collected water through a nearby, *ex situ* treatment system, which uses granulated activated carbon, reactive iron, or similar treatment options.

J. Hopkins + RTG ~~did not~~ also proposed passive ~~for~~ collection + treatment with air strippers.

The passive treatments proposed in this plan could use any of these methods and are conceptual in nature. No engineering feasibility analyses were performed and the proposed remedial actions were not evaluated with regard to changing site conditions over time. Before implementation of any

268

remedy, an evaluation will be done to determine the most appropriate, effective, implementable, and cost-effective remedy for each plume of contaminated groundwater. The result of these evaluations will be presented as part of ASAP or in a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA), along with the data used to make the decision. It is possible that, as a result of these evaluations, different remedial actions will be selected for the different contaminant plumes in RFETS groundwater.

Assumptions

The proposed conceptual remedial actions for treatment of contaminated groundwater were developed using the following assumptions:

- RFETS groundwater will not be used for domestic or other consumptive purposes, and there are no pathways for contaminated groundwater to directly impact human receptors.

- Groundwater will be managed or remediated to protect surface water and to minimize potential ecological impacts due to entering the surface water system.

- Source removals or containment of subsurface soil sources will be designed to prevent further migration of groundwater containing contaminant concentrations greater than 100 x MCLs.

- Remediation and plume management will preserve wetlands where possible.

- Proposed actions will be implemented using cost-effective methodologies.

- Based on preliminary analysis, passive groundwater treatment or containment would appear to be the preferred remedial alternative for most contaminant plumes in RFETS groundwater.

- Performance monitoring will be conducted for all remediation systems to verify effectiveness.

269

- The remediation and management decisions described herein are based on the existing data set for contaminant plumes, as well as on known technologies that are believed to be applicable to treatment of RFETS groundwater.

- For this plan, the proposed actions are assumed to be passive treatment or containment devices. Passive treatment systems will be sited downgradient from the sources and coincident with the Tier I boundary within the plume, or where otherwise practicable and feasible. The actual remedial actions and location of these actions will be decided on a case-by-case basis and detailed in an IM/IRA or Proposed Action Memorandum (PAM) before implementation.

- An alternatives analysis for any proposed action will be presented as part of ASAP or as an IM/IRA decision document.

- As per RFCA, contaminant plumes in RFETS groundwater which are stable and do not impact surface water above action levels will not require cleanup.

- All remedial actions will be consistent with the proposed end-state of RFETS.

4.4 POTENTIAL CLEANUP ACTIONS

Using available information, the following potential actions were conceptually developed for each major VOC contaminant plume in groundwater. As contaminated seeps are the most distal ends of these contaminated groundwater plumes, these will be managed through cleanup of groundwater sources, natural attenuation, and/or interception at or upgradient of seep locations in accordance with the action level framework and the ER ranking. Further analysis of alternatives for feasibility, cost effectiveness, and suitability must be performed before initiating any action. Figure 4-1 shows the conceptual location of the groundwater actions.

210

4.4.1 Potential Action for the 881 Hillside Drum Storage Area Plume

The final remedy proposed for OU 1 is to excavate those soils containing VOC concentrations greater than the Tier-I action levels. The volume of the source area requiring excavation is estimated at between 900 and 1,900 cubic yards of colluvium and weathered bedrock. Excavating the source will also remove much of the contaminated groundwater above Tier I action levels (Sampling and Analysis Report, 1996). After demonstrating that this proposed remedy has been effective, and that the source and much of the resulting contaminated groundwater have been removed, the French Drain and recovery well are expected to be removed from operation.

This remedial action will be protective of surface water quality, and should reduce or eliminate any potential long-term stress to environmental receptors of contaminants that may reach Woman Creek.

4.4.2 Potential Action for the Mound Site Plume

Cleanup of the Mound Site contaminated groundwater plume will consist of excavating the subsurface soil exceeding Tier-I action levels for soil cleanup criteria for VOCs. Contaminated materials in Trench T-1 will also be removed using the same criteria. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches South Walnut Creek. Interception of the contaminant plume will be accomplished by making improvements to the existing seep collection system at SW059. The contaminated water is expected to be treated by a passive system installed along the south bank of South Walnut Creek.

Containment and treatment of the contaminant plume in Mound Site groundwater will result in a reduction of risk to the environment posed by uncontrolled releases of contaminated groundwater to surface water.

4.4.3 Potential Action for the 903 Pad and Ryan's Pit Plume

The proposed action is to remove contaminant sources exceeding the Tier I soil action levels for VOCs in soil from the 903 Pad area. Removal of the subsurface soils in the Ryan's Pit area has

already been completed. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches Woman Creek. The contaminated water is expected to be treated by a nearby passive system.

4.4.4 Potential Action for the Carbon Tetrachloride Spill Plume

There are two potential actions identified for this groundwater contaminant plume: (1) source removal by using shallow recovery wells to remove as much of the free-phase carbon tetrachloride as possible, and (2) removal of the contaminated soils, adjacent tanks, and associated piping. At this time, the building infrastructure in the area is containing this plume. Monitoring must continue to ensure that contaminated groundwater does not impact surface water. After removal of the infrastructure, near surface capture of this plume may be required to minimize impacts to surface water. If required, the captured water will be treated at a nearby passive treatment plant. This area may be capped as part of the 10-Year Plan. The impact on groundwater must be determined to see if additional controls are necessary.

4.4.5 Potential Action for the East Trenches Plume

Source remediation for Trenches T-3 and T-4 was completed in 1996 to remove subsurface soils that exceed the applicable RFETS soil cleanup criteria for VOCs. This action removed the contaminant source of this contaminated groundwater plume. The remedial action proposed for the remaining contaminated groundwater plume is to install a near-surface plume capture system near the distal end of the plume, and to use passive technologies to treat the contaminated groundwater.

4.4.6 Potential Action for the IA Plume

This groundwater contaminant plume may not require action because source removal and D&D activities ~~will~~ should remove contaminant sources, the source of water in the plume will be reduced over time as capping and/or regrading and revegetation reduces infiltration, and water loss from the RFETS ~~plumbing~~ utilities will be eliminated. Monitoring must continue to ensure that contaminated groundwater does not migrate, or create a threat to surface water. An upgradient groundwater barrier is not recommended as preliminary calculations indicate that only 15 percent of the present recharge (precipitation plus groundwater influx) to the IA could be diverted by an upgradient barrier, preventing approximately 4 gallons per minute of groundwater flux from entering the IA.

4.4.7 Potential Actions for Additional Plumes

Present Landfill Plume

An interim remedial action has been installed at this location to collect the contaminated groundwater and leachate flowing from the landfill for treatment. This gravity-driven system consists of cement vaults for collecting the contaminated water. Treatment includes a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents. Contaminated water is treated to comply with established cleanup levels. This treatment should effectively mitigate the potential ecological risk from the contaminants of concern. The treatment system may change or be eliminated once the Present Landfill cap is installed, because groundwater migration may no longer be a concern. Marla / Schmuck should review + approve

Solar Ponds Nitrate Plume

Proposed remedial actions for the groundwater nitrate plume, if required, will be developed at a later date, based on final cleanup standards and site-specific hydrogeologic conditions. No source removal is planned for nitrate-containing media. However, a cap/cover is being considered, which would reduce the groundwater recharge and the flow through the nitrate-contaminated soils.

Recommendations from the Working Group, if approved by the Water Quality Control Commission (WQCC), will change the stream classification for nitrates from drinking water to agricultural. There is some possibility that this surface water will be used for irrigation. Measures are being implemented which will restrict use of this water for domestic use. If the drinking water classification is lifted, then the nitrate concentrations seen in the surface water as a result of the nitrate plume are acceptable for all of the remaining uses, and could be of benefit for irrigation.

273

PU&D Yard Plume

A limited field investigation will be completed in 1997 to determine the impact to surface water. This ~~will~~ may be followed by a source removal the same year. The limited field investigation will determine whether groundwater remedial action(s) are required to protect surface water.

Other 881 Hillside Groundwater Contamination

No action is required to mitigate this plume as it is not impacting, or expected to impact surface water. Any point sources around the building are expected to be dealt with during building demolition.

Old Landfill Groundwater Contamination

The VOC contaminated groundwater associated with the Old Landfill is limited in extent, closely related to ~~the~~ a small source area, and is not a threat to surface water. Therefore, this contaminated groundwater does not require any action.

Walnut Creek Drainage Groundwater Contamination

It is most likely that the contamination in this area has migrated from a source upgradient of the Present Landfill, potentially the PU&D Yard (see above). Contaminated groundwater in this area will be addressed as part of the remedy for the upgradient plume.

4.5 PLUME RANKING

Sources or contaminant plume above action levels that are determined to be candidates for remedial actions have been prioritized to determine the sequence in which remediation will occur. To accomplish this task, a methodology was developed by CDPHE, EPA, K-H, and RMRS staff to rank the known environmental risks at RFETS and is outlined in the "Environmental Restoration (ER) Ranking" (RMRS 1995).

The ER ranking is currently being updated to incorporate the new action levels. Sites are ranked using the following criteria: 1) concentrations of contaminants present in soil, subsurface soil, and groundwater; 2) impact to surface water; and 3) the potential for further release which quantifies the possibility that source material will continue to release contaminants into the environment. The resulting prioritized list is used to determine the general order in which to implement remedial actions.

This methodology incorporates a very conservative approach. As a result, IHSSs, areas and groundwater plumes where formal risk assessments have determined that there is no unacceptable risk may rank higher than expected on the prioritized list.

The Working Group recommended that the groundwater plumes be prioritized separately from the contaminant sources to allow the groundwater actions to be initiated separately from the source removal actions. The methodology for ranking the groundwater plumes follows:

1) **Score Ratio**: Analytical data for VOCs in groundwater since 1990 were compared to the proposed Tier II action levels, and a ratio of the analytical result to Tier II action level value was calculated. The maximum ratio for each analyte within the contaminant plume was tabulated, and a total score for each groundwater plume was calculated by summing the maximum ratios. The resulting summed values were then converted to a Score Ratio using Table 4-1.

2) **Impact to Surface Water**: A rating of 1 to 3 was assigned to each plume based on the evaluation of whether or not the groundwater contaminant plume was impacting surface water at Tier I action levels (a rating of 3), had the potential or was impacting surface water at Tier II levels (a rating of 2), or did not pose a threat to surface water at this time (a rating of 1).

3) **Potential for Further Release**: A rating of 1 to 3 is assigned based on an evaluation of whether or not there is a potential for contaminants to continue to migrate into groundwater (i.e., is an uncontained source present?). If there is probably free product present, a rating of

3 is assigned, if high concentrations of contaminant are present in soil, a rating of 2 is assigned and if there is probably no uncontained source present, a rating of 1 is assigned.

Table 4-1 Converstion Table for Scores

Summed Groundwater Ratios	*Score Ratio*
> 20,000	10
10,001 - 20,000	9
5,001 - 10,000	8
1,001 - 5,000	7
501 - 1,000	6
251 - 500	5
126 - 250	4
76 - 125	3
26 - 75	2
1 - 25	1

The ER Ranking was recalculated in September 1996 using the new action levels and standards, and including the groundwater contaminant plumes. Table 4-2 provides the rankings of the groundwater contaminant plumes.

The following is an example showing how the three factors were used to generate the ranking for the 903 Pad groundwater contaminant plume. Concentrations of VOCs in groundwater in the 903 Pad and Ryan's Pit plume were identified and compared to the appropriate Tier II values. The maximum ratios for each contaminant that exceeded Tier II action levels were summed, which equaled a value of 603. Using Table 4-1, this value equated with a Ratio Score of 10.

Next, the impact to surface water was evaluated. Because the contaminants are believed to be impacting surface water near Tier II levels, the a factor of 2 was used. Finally, the potential for further release was believed to be high and a factor of 3 was assigned, based on the belief that there is free product underneath the 903 Pad that is still being released into the groundwater.

Multiplying the Ratio Score of 10, times the impact to a surface water impact factor of 2, times the factor for potential for further release of 3, generated a ranking score of 60.

Table 4-2 Plume Ranking

Plume	*Priority Score*	*Ranking*	*Comments*
Mound	30	11	
903 Pad and Ryan's Pit	20	12	Ryan's Pit source removed
East Trenches	20	13	Sources removed
Solar Ponds	20	17	Ranking due to nitrate concentrations
Present Landfill	18	19	Groundwater presently collected/treated
PU&D Yard	16	22	
881 Hillside Drum Storage Area	10	26	
Carbon Tetrachloride Spill	10	27	
IA	10	28	
Building 881 Area	9	32	Below Tier I action levels
Old Landfill	8	35	Below Tier I action levels

277

5.0 NEXT STEPS

Additional data must be collected and/or analyzed before implementing actions. Not all groundwater contaminant plumes and sources are characterized sufficiently to implement an action, and appropriate methodologies for collection and treatment must be identified. The ecological impacts of groundwater collection and treatment must be determined, as collection of the distal plume boundaries may irreparably damage wetlands and seeps.

Before implementation of any remedy, a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA) or PAM must be prepared, and an engineering design must be completed.

Based on the currently available information, following are the steps already completed towards groundwater remediation, and the proposed next steps:

- Soils in OU 1 881 Hillside Drum Storage Area (IHSS 119.1) that contain contaminant concentrations above action levels may be excavated, removing material above the Tier I Action Level. Because the source of groundwater contamination would be removed, the use of the French Drain system and recovery well may no longer be necessary. After monitoring demonstrates the effectiveness of the remedy, these will be removed from service.

funded? The seep near Woman Creek will be evaluated to determine whether it is related to the 881 Hillside Drum Storage Area, and if there is an impact to surface water above action levels.

- The source of the Mound plume is anticipated to be remediated as an accelerated action. Pre-remedial investigations were completed in 1996 to delineate the extent of the contaminant source for this plume. Further pre-remedial investigations to determine the extent of the distal end of the groundwater contaminant plume, and effective, passive treatment methodologies are expected to continue in the near future. Gravity-flow passive treatment systems will be the preferred option.

218

- The sources of the 903 Pad and Ryan's Pit plume are scheduled to be removed. The Ryan's Pit source has already been characterized and remediated. Pre-remedial investigations are proposed to determine the extent of the source. The distal ends of the groundwater contaminant plumes require better definition in order to appropriately design site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred option.

- A pre-remedial investigation is proposed for the carbon tetrachloride spill plume (IHSS 118.1) to better define the source, and to evaluate remedial actions. A limited pump and treat system may be installed due to the large amount of free product present in a limited area. If required, after removal of the surrounding buildings and associated footing drain systems, a passive collection and treatment system may be installed to contain the dissolved phase of this plume. This system would be located along the post-building removal, downgradient flow path near the impacted drainage.

Source removal?

- The sources for the East Trenches plume have been removed. Accelerated actions were completed in 1996 to excavate Trenches T-3 and T-4, and materials above the Tier I action levels were removed. The distal end of this groundwater contaminant plume requires better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred options.

- The IA plume will continue to be monitored to ensure that there is no increase in migration, and that there is no impact to surface water quality.

- Groundwater treatment systems need to be investigated to determine the optimum treatment methodology.

- The unknown extent of the chlorinated solvent plumes associated with the PU&D yard (IHSS 170, 174a, and 174b) is a data gap. Because the nature of the southern boundary of these plumes is undetermined, the potential impact to surface water cannot be evaluated. A limited characterization investigation ~~will~~ is proposed to be conducted in 1997 to determine the extent of the plume, and to determine the location, nature and size of the source material. Previous investigations suggest that the contaminant source(s) may be located immediately east of the

279

known PU&D yard boundary. Source removal is expected to follow in 1997 if a contaminant source can be defined.

or regrading and revegetation

lots talk

- Soil vegetative caps ~~or~~ covers may be used throughout RFETS where necessary to limit natural recharge caused by precipitation from leaching of contaminants in the unsaturated zone and into groundwater. This would ~~greatly~~ aid in reducing the movement of groundwater through the IA, and thereby reduce the mobility of the contaminant plumes. Subsurface sources of groundwater contamination would be removed where practical. At the end of the D&D/remediation phase, the plant water supply and sanitary sewer will be shut off. This will eliminate a major source of groundwater recharge for the IA, and should greatly reduce the mobility contaminant of the IA and carbon tetrachloride spill plumes.

Further analysis is required to determine optional intercept locations, actual treatment methodologies, and cost-effective project planning and scheduling.

The ER Ranking scheduled to be completed in 1996 and the proposed ranking of groundwater plumes presented in Section 4.5 provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

380

6.0 REFERENCES

DOE, 1992a, *Final Groundwater Assessment Plan*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, February.

DOE, 1992b, *Final Historical Release Report for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, June.

DOE, 1993, *Final Groundwater Protection and Monitoring Program Plan for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, October.

DOE, 1994, *RCRA Report*.

DOE, 1995, *Intrinsic Remediation Monitoring Task 1 Evaluation Report*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, March.

EG&G, 1992, *OU 2 Domestic Water Supply Simulations*, (Internal Report), EG&G Rocky Flats, Golden, Colorado, September, 9p.

EG&G, 1994, Technical Memorandum Final Work Plan OU 7, Volumes 1-4, RF/ER-94-00044, September.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

EG&G, 1995c, *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site*, Volume III of the Sitewide Geosciences Characterization Study, EG&G Rocky Flats, Golden, Colorado, January.

EG&G, 1995d, *1994 Well Evaluation Report for the Rocky Flats Environmental Technology Site (Final)*, EG&G Rocky Flats, Golden, Colorado, March.

EPA, 1992, *Chemical Enhancements to Pump-and-Treat Remediation*, U.S. Environmental Protection Agency EPA/540/S-92/001.

EPA, 1994, *Draft Soil Screening Guidance*, U.S. Environmental Protection Agency, EPA/540/R-94/101.

RMRS, 1995, *Environmental Restoration Ranking*, RMRS Rocky Flats, Golden, Colorado, September 27.

RMRS, 1996a, White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company, August 16, 1996.

Date: May 16, 1996
To: Annette Primrose
From: Ed Mast
RE: Revision of the Southwest boundary on Figure 3-1 Tier II Well Location Map with Composite Plume Extent for Concentrations > MCLs

There are 339 soil gas sampling points and 26 separate locations where groundwater has been collected at the Old Landfill. Nine soil gas sampling points in two small anomalies (clusters) had reportable concentration of TCE of >1.0 µg/L. The two small TCE anomalies identified by the soil gas results ("A" and "B" Areas) at the Old Landfill have aerial extents of approximately 50 ft x 50 ft and 64 ft x 64 ft respectively, as reported in the OU5 RI/RFI Report which more accurately represents the extent on the contaminant ~~contaminate~~ "plume" in the Old Landfill then the Groundwater Conceptual Plan Map (Attachment 1, Figure 3-1 Tier II Well Location from the Groundwater Conceptual Plan for the RFETS). Four water sampling events out of 112 in the area in and around the Old Landfill had TCE concentrations above the MCL (with one of the samples being a duplicate sample and two of the samples located north of the landfill). See Attachment 2, Groundwater Data, a U in the Qual(ifer) column indicates a non-detect. The lobe of the contaminant ~~contaminate~~ plume extending into the Old Landfill as shown in Attachment 1 is based on two TCE hits in one well.

The OU5 RI/RFI Report concluded that the soil and groundwater samples collected from the boreholes within the anomalies, Area "A" and "B" (see Attachment 3, Figure 2.4.3.3-1 from TM15 of the OU5 Work Plan) confirmed the results of the soil gas survey, 331 non-detects out of 339 sampled locations. The VOCs detected by the soil gas survey at each location were also detected in the soil and groundwater samples. The conclusion of this memorandum (and the OU5 RI Report) is that a large TCE plume as shown in the Groundwater Conceptual Plan does not exist at the Old landfill.

Attachment 1, Figure 3-1 from the Groundwater Conceptual Plan for the RFETS shows a composite plume representing groundwater sampling results for trichloroethane (TCE), tetrachloroethene (PCE), carbon tetrachloride (CCl4) and vinyl chloride (VC). The individual contaminant ~~contaminate~~ work maps generated to make the composite contaminant ~~contaminate~~ map indicate that the only contaminate of the above four that makes up the plume in the area in and around the Old Landfill (IHSS 115) is TCE. The bottom lobe of the large composite contaminant ~~contaminate~~ plume to the southwest is the former Operable Unit 5, IHSS 115, the Old Landfill (closed in 1968). This landfill area is further highlighted by a series of question marks (?). The existence of a groundwater plume is this area was not a finding in the Final OU5 RI/RFI Report delivered to the regulatory agencies in April 1996.

During the investigative stage of the OU5 remedial investigation there were a number of activities that were conducted over the Old Landfill that substantiate the findings of the OU5 RI Report of two small, less than 64 sq ft, TCE "plumes". Initially, a real time soil gas survey was conducted as part of the field investigations at the Old Landfill . The

283

purpose of this survey was to provide screening level data concerning the presence or absence of VOCs. If during the course of this survey, anomalous readings were encountered, then the anomalies would be further investigated by additional soil gas sampling on a tighter grid spacing and then ultimately by the subsequent drilling of soil borings within the plumes and installation of groundwater monitoring wells if and when groundwater was encountered.

The Work Plan specified that soil gas samples be collected on a 100 foot grid spacing in the area of the landfill, on a 40 foot equilateral grid spacing down gradient from the landfill and on a 20 foot grid spacing in areas where anomalies were encountered. A total of 339 actual locations were sampled and an additional 131 samples collected for duplicates, verification and anomaly chases for a total of 480 soil gas samples (for additional information regarding the sampling procedure and results please see Technical Memorandum (TM)15 to the OU5 Work Plan). Of the 339 locations sampled, there were nine samples at which TCE (also PCE) exceeded the reporting limits of 1.0 μg/L (the detection limit was 0.25 μg/L). These nine samples were clustered in two locations, Area "A" and Area "B" (see Attachment 3, Figure 2.4.3.3-1 from the OU5, TM15 - Amended Field Sampling Plan).

In Area "A", two soil gas samples were observed to exhibit concentrations above the reporting limit for TCE. The maximum concentration of TCE from the soil gas sampling in this area was 19 μg/L. Area A has a surface extent of approximately 2,500 sq ft (an area equivalent to about 50 ft x 50 ft).

Following the soil gas sampling, two wells were completed in Area "A", 60993 and 61093. Well 60993 was dry, and well 61093 completed in bedrock was developed and sampled on two separate occasions with the following results for TCE:

Location	Date Sampled	Result (μg/L)	Tier 2 - MCL (μg/L)
61093	7/13/93	140	5.0
61093	1/25/94	50	5.0
61093	1/25/94	51 (duplicate)	5.0

In Area "B" there were seven soil gas samples that exhibited TCE concentrations above the reporting limit, with a maximum concentration of 28 μg/L. PCE was also found at eight locations in this area, with a maximum concentration of 7.6 μg/L. Area "B" has a surface extent of approximately 4,100 sq ft (an area equivalent to about 64 ft x 64 ft). Subsequent to the soil gas sampling, three borings/wells were completed in this area, 58393, 58493 and 58593. Of the three borings completed in this area, water was encountered in only 89593. The well was sampled on December 21, 1994 The result was a non-detect for TCE.

The relationship between sample locations and the results are posted on Attachment 4.

File ED_LIST.TAB

Listing of TCE data for Well 61093 and surrounding wells   May 15, 1996

	OBS	LOCATION	SAMPLE	SDATE	ANALYTE	RESULT	UNITS	DETECT	QUAL	VAL
	1	43392	GW03968IT	12/14/92	TRICHLOROETHENE	0.80	UG/L	0.2		V
	2	43392	GW01237WC	09/22/93	TRICHLOROETHENE	1.00	UG/L	0.1		V
	3	43392	GW01590WC	11/30/93	TRICHLOROETHENE	1.00	UG/L	0.1		V
UP	4	43392	GW00379GA	03/03/94	TRICHLOROETHENE	1.00	UG/L	0.2		V
	5	43392	GW00842GA	05/17/94	TRICHLOROETHENE	2.00	UG/L	0.2		V
	6	43392	GW01232GA	08/17/94	TRICHLOROETHENE	2.00	UG/L	0.2		V
	7	43392	GW01842GA	12/05/94	TRICHLOROETHENE	2.00	UG/L	0.2		V
	8	43392	GW02166GA	02/27/95	TRICHLOROETHENE	1.20	UG/L	0.5		V
	9	56994	GW02089GA	02/03/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	10	5786	G57860290001	02/22/90	TRICHLOROETHENE	3.00	UG/L	5.0	J	
	11	5786	GW00057IT	07/26/90	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	12	5786	GW00545IT	10/12/90	TRICHLOROETHENE	3.00	UG/L	.	J	A
	13	5786	GW01051IT	03/28/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	14	5786	GW01310IT	05/22/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	15	5786	GW01764IT	09/16/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	16	5786	GW02057IT	12/14/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	17	5786	GW02488IT	02/18/92	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	18	5786	GW02819IT	04/29/92	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	19	5786	GW00228WC	03/17/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	20	5786	GW00807WC	05/25/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	21	5786	GW00331GA	02/24/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	22	5786	GW00857GA	05/18/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	23	5786	GW02161GA	02/27/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
DN	24	57894	GW50141AS	01/22/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	25	57894	GW50161AS	01/22/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	26	58094	GW50102AS	12/21/94	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	27	58094	GW50103AS	12/21/94	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	28	58594	GW50104AS	12/21/94	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	29	59493	GW01024WC	06/24/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	30	59493	GW01166WC	08/11/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	31	59493	GW00422GA	03/14/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
SIDE	32	59493	GW00741GA	05/09/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	33	59493	GW01247GA	08/18/94	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	34	59493	GW01618GA	10/20/94	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	35	59493	GW50113AS	01/04/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	36	59493	GW50114AS	01/04/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	37	59493	GW02176GA	03/09/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	38	59593	GW01025WC	06/24/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	39	59593	GW01167WC	08/13/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	40	59593	GW00423GA	03/14/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	41	59593	GW00742GA	05/09/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	42	59593	GW01248GA	08/18/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	43	59593	GW01619GA	10/24/94	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	44	59593	GW02177GA	03/09/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
UP	45	59594	GW02058GA	01/25/95	TRICHLOROETHENE	3.00	UG/L	0.5		V
SIDE	46	59694	GW02202GA	03/07/95	TRICHLOROETHENE	2.00	UG/L	0.5		V
DN	47	59793	GW50133AS	01/15/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V

Attachment 2
Groundwater Data

286

	48	59993	GW50001AS	07/06/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	49	59993	GW50148AS	01/23/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
DN	50	60093	GW50002AS	07/06/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	51	60293	GW50004AS	07/06/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	52	60293	GW50143AS	01/22/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	53	60293	GW50144AS	01/22/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
	54	60893	GW50010AS	07/07/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	55	61093	GW50012AS	07/13/93	TRICHLOROETHENE	140.00	UG/L	5.0		V
	56	61093	GW50151AS	01/25/95	TRICHLOROETHENE	50.00	UG/L	10.0		V
	57	61093	GW50154AS	01/25/95	TRICHLOROETHENE	51.00	UG/L	10.0		V
	58	63893	GW50121AS	01/04/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
UP	59	63893	GW50120AS	01/05/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
UP	60	63993	GW50119AS	01/05/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
SIDE	61	64093	GW50118AS	01/05/95	TRICHLOROETHENE	10.00	UG/L	10.0	U	V
✓	62	7086	G70860290001	02/22/90	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	63	7086	G70860524021057	05/24/90	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	64	7086	GW00151IT	07/20/90	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	65	7086	GW00541IT	10/19/90	TRICHLOROETHENE	5.00	UG/L	5.0	U	
	66	7086	GW01293IT	05/14/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
DN	67	7086	GW01682IT	09/06/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	68	7086	GW02051IT	12/06/91	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	69	7086	GW02401IT	02/17/92	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	70	7086	GW02820IT	04/28/92	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	71	7086	GW03359IT	08/14/92	TRICHLOROETHENE	5.00	UG/L	5.0		
	72	7086	GW03710IT	11/06/92	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	73	7086	GW00229WC	03/08/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	74	7086	GW00808WC	06/03/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	75	7086	GW01327WC	09/20/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	V
	76	7086	GW01687WC	12/10/93	TRICHLOROETHENE	5.00	UG/L	5.0	U	Y
	77	7086	GW00332GA	02/23/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	78	7086	GW00838GA	05/16/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	79	7086	GW01314GA	08/25/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	80	7086	GW01722GA	11/21/94	TRICHLOROETHENE	0.50	UG/L	0.5	U	Y
	81	7086	GW02206GA	03/10/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	82	71494	GW02241GA	03/14/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	83	P416489	GW01567WC	11/22/93	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	84	P416489	GW00198GA	02/10/94	TRICHLOROETHENE	0.10	UG/L	0.1	U	V
UP	85	P416489	GW00687GA	04/26/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	86	P416489	GW01209GA	08/16/94	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	87	P416489	GW01690GA	11/08/94	TRICHLOROETHENE	0.71	UG/L	0.5		V
	88	P416489	GW02186GA	03/07/95	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	89	P416489	GW02458GA	04/20/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	Y
	90	P416589	GW01568WC	11/21/93	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	91	P416589	GW00199GA	02/14/94	TRICHLOROETHENE	0.10	UG/L	0.1	U	V
UP	92	P416589	GW00688GA	05/05/94	TRICHLOROETHENE	0.20	UG/L	0.2	U	V
	93	P416589	GW01210GA	08/18/94	TRICHLOROETHENE	0.50	UG/L	0.5	U	JA
	94	P416589	GW01691GA	11/07/94	TRICHLOROETHENE	0.50	UG/L	0.5	U	V
	95	P416589	GW02051GA	01/30/95	TRICHLOROETHENE	0.50	UG/L	0.5	U	V

96	P416689	GW01569WC	11/22/93	TRICHLOROETHENE	4.00	UG/L	0.5		V
97	P416689	GW00200GA	02/14/94	TRICHLOROETHENE	3.00	UG/L	0.1		V
98	P416689	GW00689GA	04/28/94	TRICHLOROETHENE	2.00	UG/L	0.2		V
99	P416689	GW01211GA	08/18/94	TRICHLOROETHENE	6.30	UG/L	0.5		V
100	P416689	GW01692GA	11/07/94	TRICHLOROETHENE	4.20	UG/L	0.5		V
101	P416689	GW02052GA	01/30/95	TRICHLOROETHENE	3.20	UG/L	0.5		V
102	P416689	GW02460GA	04/24/95	TRICHLOROETHENE	3.51	UG/L	0.5		Y
103	P416789	GW01570WC	11/23/93	TRICHLOROETHENE	24.00	UG/L	0.5		V
104	P416789	GW00201GA	02/14/94	TRICHLOROETHENE	2.00	UG/L	0.1		V
105	P416789	GW00690GA	04/28/94	TRICHLOROETHENE	3.00	UG/L	0.2		V
106	P416889	GW01571WC	11/23/93	TRICHLOROETHENE	5.00	UG/L	0.5		JA
107	P416889	GW00202GA	02/14/94	TRICHLOROETHENE	4.00	UG/L	0.1		V
108	P416889	GW00691GA	04/28/94	TRICHLOROETHENE	4.00	UG/L	0.2	D	Z
109	P416889	GW01213GA	08/17/94	TRICHLOROETHENE	5.00	UG/L	0.2		V
110	P416889	GW01694GA	11/08/94	TRICHLOROETHENE	3.30	UG/L	0.5		V
111	P416889	GW02187GA	03/07/95	TRICHLOROETHENE	3.00	UG/L	0.2		V
112	P416889	GW02462GA	04/20/95	TRICHLOROETHENE	3.55	UG/L	0.5		Y

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Ask Rotha

288

Chris Dayton Comments

On K 9/s Put refs.

? Purpose of doc
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? gw panel
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~~Search for acronym~~

Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site

— Plumes moving slow not stagnant

← say technical then have
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OSWER Directive #

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DRAFT REVISED

Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site

Rocky Mountain Remediation Services, L.L.C.

Environmental Restoration/Waste Management

Sitewide Actions

September 1996

292

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Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site

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Sitewide Actions

September 1996

293

TABLE OF CONTENTS

294

FIGURES

295

TABLES

296

EXECUTIVE SUMMARY

The Groundwater Conceptual Plan provides a basis for cleanup and management of contaminated groundwater at the Rocky Flats Environmental Technology Site (RFETS) consistent with the Rocky Flats Cleanup Agreement (RFCA) Preamble, and the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils*. This plan was originally issued in March 1996, but has been revised to reflect the final RFCA ~~guidance~~, and to include additional groundwater plume data.

Comment Is that Plan Source Goal = GW of under RFCA

Addressing groundwater on a sitewide basis allows for effective coordination of groundwater activities, and provides consistency in addressing groundwater contamination. Domestic use of groundwater at RFETS will be prevented through institutional controls, therefore, the goal is to manage or cleanup groundwater to protect surface water quality for all agreed-upon uses. In addition, the Groundwater Conceptual Plan identifies, describes, and ranks the principal groundwater contaminant plumes to provide a planning basis for funding and implementation of groundwater actions.

The lateral extent and spread of contaminants in RFETS groundwater is limited by hydrogeologic conditions, therefore, the contaminant plumes are relatively stable. In addition, groundwater discharges to surface water before leaving RFETS, and there is a natural vertical barrier to downward migration of contaminated groundwater. Low-permeability claystones form a barrier at least 500-feet thick between contaminated groundwater at RFETS and the Laramie/Fox Hills aquifer.

The volatile organic compound (VOC) contaminant plumes in groundwater ~~have the most potential~~ are the most likely to impact surface water, and are the primary focus of the Groundwater Conceptual Plan. Contaminant plumes with other, inorganic, constituents are addressed in this plan where surface water ~~is~~ may be impacted above action levels. The plumes are defined based on the RFCA two-tiered groundwater action levels which are protective of surface water uses as well as ~~protective of the~~ ecological resources.

The groundwater Tier I action levels are used to identify highly contaminated areas as potential cleanup targets and are defined as 100 x Federal Drinking Water Maximum Contaminant Level

217

(MCL) for VOCs. Tier II action levels are used to identify contaminated groundwater that may impact surface water and are defined as the MCL for individual constituents. where MCLs not present, use resid. dr. w. PPRG

The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels ~~are:~~ (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed that do not exceed the Tier I action levels, but may have the potential to impact surface water, include those at the Present Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard. spell out acronym

not in fig. 1.1

Proposed cleanup actions consist of source removal or containment, with capture and treatment or management of the contaminated groundwater. Using available information, potential actions were conceptually developed for each major groundwater contaminant plume. Based on capture and treatment effectiveness, installation and operating costs, and plant infrastructure requirements, passive captive and treatment methods were the preferred conceptual actions. Before each cleanup action can begin, analyses must be done to select the specific cleanup alternative, and to perform engineering design. Additional data may be needed to select the appropriate treatment systems and ensure the proper placement of cleanup systems.

The groundwater contaminant plumes were ranked based on the methodology previously developed to provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

298

1.0 INTRODUCTION

The Groundwater Conceptual Plan was originally developed as a joint effort between the Department of Energy, Rocky Flats Field Office (DOE/RFFO), Kaiser-Hill Company, L.L.C. (K-H), Rocky Mountain Remediation Services, L.L.C. (RMRS), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). This revised plan incorporates the final Rocky Flats Cleanup Agreement (RFCA) (July 19, 1996), and guidance from the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils Working Group ("the Working Group"). This Working Group was formed to:

- Provide a basis for future decision making,
- Define the common expectations of all parties, and
- Incorporate land- and water-use controls into site cleanup.

The Groundwater Conceptual Plan was originally issued in March 1996, and has been revised to incorporate changes in RFCA, and additional information on plumes.

1.1 ROCKY FLATS CLEANUP AGREEMENT AND ACCELERATED SITE ACTION PROJECT (ASAP)

RFCA is an agreement between DOE/RFFO, EPA, and CDPHE to ensure the effective and efficient cleanup of RFETS. The RFCA Preamble mandates that environmental cleanup will be implemented through an integrated and streamlined regulatory approach. The RFCA preamble also defines the approximate areal extent of the five future conceptual land uses: (1) capped areas underlain by waste disposal cells or contaminated materials closed in-place; (2) an industrial-use area; (3) restricted open space; (4) restricted open space because of low levels of plutonium contamination in surface soils; and (5) unrestricted open space.

The RFCA Preamble states that the goal of soil and groundwater management and cleanup is the protection of surface water quality for the designated uses. Proposed actions will be designed to

249

protect ecological resources and ~~to protect~~ the proposed appropriate industrial or open space uses. Groundwater will not be used for any purposes at RFETS, except as related to cleanup activities. ASAP was developed as an accelerated strategy to reduce risks and close RFETS. The ASAP strategy was used to develop the Integrated Site Baseline (ISB), and the ~~Ten~~ 10 Year Plan, a comprehensive action plan to implement the objectives stated in the RFCA Preamble, and to ensure that, after cleanup, surface water and groundwater leaving the site will be acceptable for any use.

no! 10-Year Plan was issued by the Secretary of Energy as a proposal for cleanup in 10 yrs.

The Groundwater Conceptual Plan is based on the ASAP strategy, and incorporates the RFCA Preamble objectives and the *Action Levels and Standards Framework for the Surface Water, Ground Water, and Soils*. This plan provides a basis for cleanup and management of contaminated groundwater at RFETS to protect surface water quality and ecological resources, and is the basis for the groundwater cleanup in the ISB. and the 10 Year Plan?

1.2 PURPOSE OF THE GROUNDWATER CONCEPTUAL PLAN AT RFETS

Groundwater at RFETS is present in the shallow, unconsolidated sediments and subcropping bedrock throughout the site. In the past, each Operable Unit (OU) investigated groundwater within its boundaries without addressing influences from upgradient sources. However, groundwater is not limited by OU or Individual Hazardous Substance Site (IHSS) boundaries. Several sources may contribute to a single groundwater plume, and groundwater plumes may cross several OUs and contribute to surface water contamination a great distance from the source location. Figure 1-1 shows the location of the principal areas discussed in the text.

figure show go behind the pg.

The Groundwater Conceptual Plan addresses groundwater on a sitewide basis, to allow effective coordination of groundwater activities, and establish a consistent approach to addressing groundwater contamination. While remediation of groundwater contaminant plumes must consider both the source and the associated groundwater plume, groundwater plume remediation can be performed independently of source remediation. Because there is no exposure pathway to humans from contaminated groundwater, the programmatic goals are to protect surface water and the environment, and limit potential contaminant migration (to the extent practicable).

300

The three specific goals of the Groundwater Conceptual Plan are to:

1) Identify and describe the principal contaminant plumes in groundwater;

2) Rank the contaminant plumes for the purpose of establishing the priority for cleanup actions, in accordance with the method outlined in the "Environmental Restoration (ER) Ranking" (~~RMRS 1995~~ RFCA Attachment 4?); and

3) Provide an initial planning basis for funding and the related implementation schedule for groundwater cleanup.

To meet these goals, the Groundwater Conceptual Plan proposes cleanup and/or management of contaminated groundwater through source removal, source control, and/or treatment of dissolved-phase plumes. Contaminated seeps are also addressed, as these represent the distal ends of the contaminated groundwater plumes. The Groundwater Conceptual Plan recommends evaluating whether some areas of contaminated groundwater may remain in place, given that the programmatic goals can be met without active intervention.

1.3 DOCUMENT ORGANIZATION

The conceptual plan for groundwater restoration is presented in five sections: (1) Section 1.0 describes the goals and purpose of the groundwater strategy, and presents the organization of the report; (2) Section 2.0 provides a summary background on groundwater at RFETS; (3) Section 3.0 presents the action levels and standards developed by the Working Group and describes the groundwater monitoring requirements; (4) Section 4.0 describes the various groundwater contaminant plumes present at RFETS and provides an overview of the proposed cleanup actions that may be used; and (5) Section 5.0 summarizes the proposed next steps.

This document also contains two appendices: (1) Appendix A is a list of acronyms used in this text, and (2) Appendix B contains the executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential (RMRS 1996a)

3001

2.0 HYDROGEOLOGY AT RFETS

A basic understanding of the hydrogeologic setting is important for evaluating the nature and distribution of contaminated groundwater at RFETS. The current reference documents for describing the sitewide geologic, hydrogeologic and groundwater geochemical data at RFETS are the "Geologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995a), the "Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site" (EG&G 1995b), and the "Groundwater Geochemistry Report" (EG&G 1995c). Much of the following discussion was derived from these reports. Unpublished plume maps from the 1995 Well Evaluation Project were modified to generate the plume configuration maps in this report.

The RFETS ~~plant site~~ is located approximately 4 miles east of the Front Range on a nearly flat-lying pediment surface, unconformably overlying nearly flat-lying bedrock (Figure 2-1). A conceptual cross-section of the local hydrogeologic setting at RFETS (Figure 2-2) illustrates that at the site, the shallow groundwater flows through two separate water-bearing layers, known as hydrostratigraphic units. These units are defined based on observed differences in hydrologic and geochemical characteristics for each flow system. These units are generally referred to as the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). A third hydrostratigraphic unit, a permeable, deep regional artesian aquifer known as the Laramie-Fox Hills aquifer, lies below the LHSU and is used extensively as a water supply in the greater Denver area. The RFETS hydrostratigraphic units are described in the greater detail in the Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site (EG&G 1995b).

The UHSU is the predominant water-bearing unit of concern at RFETS and is considered to be equivalent to the "uppermost aquifer" as defined by the Resource Conservation and Recovery Act (RCRA). It consists of unconsolidated, sandy and gravely materials mixed with clay (i.e., alluvium, colluvium, and artificial fill), as well as weathered bedrock claystones and sandstones which are hydraulically connected to the alluvium. The LHSU consists of unweathered claystone with some interbedded siltstones and sandstones. There is a significant difference in the ability of each unit to transmit groundwater. For example, the geometric mean hydraulic conductivity value of 2×10^{-4} centimeters per second (cm/sec) for the Rocky Flats Alluvium (UHSU) is about three orders of magnitude greater than that for unweathered LHSU Laramie claystones (geometric mean of 3×10^{-7}

303

cm/sec) (EG&G 1995b). The hydraulic conductivities of LHSU materials are similar to that required for a landfill liner. Wells completed in the UHSU and LHSU generally have poor water-yielding characteristics that prevent their development as viable water sources for residential use, although a few isolated UHSU well locations (i.e., bedrock sandstones in OU 2 (EG&G 1992) and valley-fill alluvium in Walnut Creek near Indiana Street (EG&G 1995d) have sustainable well yields that could support limited household use.

The spread of individual groundwater contaminant plumes at RFETS is limited by natural hydrogeologic conditions, including: the magnitude and distribution of hydraulic conductivities and hydraulic gradients; limited aquifer extent and interception of plume fronts by hydrologic boundaries (i.e., interception of groundwater contaminant plumes by drainages); and other physical controls, such as bedrock topography and the presence of discontinuously saturated areas, that constrain and moderate groundwater and contaminant movement.

Generally, groundwater flows slowly at RFETS. For example, using Darcy's Law, the velocity of groundwater moving laterally through the Rocky Flats Alluvium in the East Trenches Area is estimated to be about 50 feet per year (assuming a hydraulic conductivity of 217.3 ft/yr, effective porosity of 0.1, and hydraulic gradient of 0.0213 ft/ft).

Because natural processes such as sorption and geochemical transformation reactions tend to attenuate the movement of organic contaminant plumes in groundwater, the velocity of contaminant movement is expected to be retarded relative to the groundwater flow velocity. Contaminants in the East Trenches Plume are expected to migrate at rates ranging from about 2.5 and 25 feet per year, based on a reasonable range of retardation factors and neglecting the effects of dispersion and diffusion. Other processes may further attenuate contaminant movement, such as diffusion of aqueous contaminants into clayey matrix materials. Therefore, in some cases, plume front movement appears to be imperceptibly slow. The apparent slow migration rate of some contaminant plumes at RFETS, although not fully understood, provides a level of confidence that temporary deferment of remedial actions at these plumes will not result in undue risks to the environment.

Groundwater in the surficial deposits of the UHSU generally flows to the east following bedrock and surface topography, and ultimately discharges to one of three stream drainages which are the main water pathways offsite. These drainages include Walnut and Woman Creeks, which receive (location on fig 1.1) groundwater flow from the IA, and Rock Creek, which receives groundwater flow from areas essentially unimpacted by RFETS activities. Surface water flow from the IA is controlled by a series of impoundments in the Walnut and Woman Creek drainages. These impoundments also intercept groundwater flow associated with the valley-fill alluvium and promote intermingling of surface water with groundwater prior to release offsite. As a result, there is no known direct hydraulic connection between impacted groundwater at RFETS and offsite domestic wells.

In partially saturated areas, alluvial UHSU groundwater has been shown to preferentially flow along predepositional channels cut into the underlying bedrock surface (see Figure 2-2). These channels are known to occur in the IA, Solar Ponds, 881 Hillside, 903 Pad, and East Trenches Areas. Groundwater flow is often concentrated within these channels, and hillside contact seeps result where these channels are cut by erosional surfaces. These channels restrict plume spreading and movement. Other hydrogeologic controls for groundwater flow and contaminant transport are hydraulic gradient, distribution of subcropping sandstones and claystones, and topography. In the IA, features such as interceptor drain systems, buried utility lines, and building foundation drains control groundwater flow.

The lithologic and hydraulic characteristics of the LHSU cause it to act as a regional confining layer for the underlying Laramie-Fox Hills aquifer. The LHSU is a natural barrier to vertical groundwater flow and contaminant transport that effectively isolates impacted UHSU groundwater from deeper strata and the Laramie-Fox Hills aquifer (RMRS 1996a). ~~At~~ In the IA the LHSU ~~is estimated to~~ measure at least 600 feet in thickness as shown in Figure 2-1 (modified from EG&G 1995a). By comparison, the average RCRA landfill is lined with only a few feet of similar material. These stratigraphic relationships, combined with an observed downward vertical hydraulic gradient, result in a LHSU groundwater flow regime that is effectively separated from the UHSU, and is predominantly vertically downward rather than horizontal. The available data from groundwater monitoring in the LHSU indicates that it is uncontaminated.

fig 2-1 doesn't show where the IA is

The available hydrogeologic and geochemical data suggest that fractures and faults are not significant conduits for downward vertical groundwater flow at RFETS (RMRS 1996a). Evidence of

305

limited shallow hydraulic communication between UHSU and LHSU groundwater was found to exist in some wells, but these occurrences do not present a pattern consistent with known fault locations.

Due to the thickness, lithology, and observed trend of decreasing hydraulic conductivity values with depth for the LHSU, it appears that the LHSU has sufficient hydrologic integrity to provide long term protection of the Laramie-Fox Hills aquifer from shallow groundwater contamination (RMRS 1996a). The executive summary of the White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN is presented in Appendix C and summarizes the hydrologic information used to reach the above conclusions.

306

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for development of the action levels and standards framework for surface water, ground water, and soils. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and all three media were considered in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (Attachment 5 of RFCA, July 19, 1996) was recently modified to incorporate the clarifications and resolutions of soil issues that were reached after RFCA was signed. The proposed soil action level changes are expected to be completed by October 18, 1996. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points ~~of~~ compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.

delete

Look in the Preamble better that put in SW site leaving acceptable for all uses.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources. This framework for groundwater action levels is based on the assumption that contaminated groundwater emerges as surface water before leaving RFETS.

Preamble: gw only use on-site related to cleanup activ!

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3.2.1 Action Levels

The Working Group has defined the action levels for groundwater ~~Volatile Organic Compounds~~ (VOCs) only, based on ~~Maximum Contaminant Levels~~ (MCLs) established under the Safe Drinking Water Act. MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated cleanups, and Tier II action levels are protective of surface water quality. This approach is described below.

Tier I

Groundwater Tier I action levels are based on 100 times the MCL (100 x MCL) and were developed to identify potential cleanup targets. Contaminant concentrations in groundwater above the Tier I action levels indicate the presence of groundwater contaminant sources which may pose a risk to surface water quality. If Tier I action levels are exceeded, an evaluation is required to determine if source removal, or other cleanup or management action is necessary to prevent highly contaminated groundwater (i.e., contaminant concentrations exceeding 100 x MCLs) from reaching surface water. (The evaluation process is described in Section 4.1). This report represents the first phase of this evaluation.

Where action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

3008

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G in 1995 to establish sitewide cleanup targets for environmental contamination.

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater above MCLs from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of RFCA Attachment 5. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. These wells are located at or near the boundaries of the composite VOC plumes shown in Figure 3-1. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	10692
10194	4087
1986	B206989
1386	

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan (IMP). The document will combine and replace two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document also will describe recent changes to the groundwater monitoring network.

The IMP will list the wells with their appropriate data quality objectives, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified, until changes proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any required performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

3.3 SUBSURFACE SOILS

? Surface Soil

Action levels for VOCs in subsurface soils were developed to be protective of surface water quality through groundwater transport of leached contaminants. As there are too many variables to accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils at RFETS, the Tier I action levels are the same as Tier I action levels for the corresponding contaminants in surface soil. These action levels are human-health risk-based for the appropriate

310
20

receptor (office work or open-space recreational user), and the approach is conservative since future land use scenarios do not include contact with subsurface soil.

Action levels for VOCs in subsurface soils were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to calculate the expected equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Subsurface soil contaminant levels that would be protective of groundwater to Tier I action levels of 100 x MCLs were then calculated. These action levels for subsurface soils and are provided in Table 4 of RFCA Attachment 5.

Tier I action levels for radionuclides in subsurface soils are the same as Tier I action levels for radionuclides in surface soils, with the total dose from multiple radionuclides calculated by the sum-of-ratios method. These action levels are the more conservative of:

- An annual radiation dose limit of 15 mrem for the appropriate land use receptor; or
- An annual radiation dose limit of 85 mrem for a hypothetical future resident assuming failure of passive control measures.

Additional subsurface soil may need to be remediated or managed to protect surface water quality or ecological resources. These additional sites will be determined on a case-by-case basis.

21
311

completed 9/24

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for development of the action levels and standards framework for surface water, ground water, and soils. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and all three media were considered in developing a sitewide strategy for RFETS.

b/n 9/1-10/4/96

sections of ~~The~~ the *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (Attachment 5 of RFCA, July 19, 1996) were released ~~was recently modified~~ for public comment with proposals to incorporate the clarifications and resolutions of issues that were reached after RFCA was signed. The proposed changes are expected to be finalized ~~completed~~ by October 18, 1996. Appendix B contains ~~these~~ final and proposed action levels and standards. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and ~~subsurface~~ soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities may ~~will~~ be different than those applied after remediation. During active remediation, the water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources.

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To LAURA BROOKS	From Annette Primrose
Co./Dept. K-H	Co. RMRS
Phone # 6130	Phone # 4385
Fax # 6406	Fax # 2623

This framework for groundwater action levels is based on the assumption that contaminated groundwater emerges as surface water before leaving RFETS.

3.2.1 Action Levels

The Working Group has defined the action levels for groundwater Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated clean-ups, and Tier II action levels are protective of surface water quality. This approach is described below.

Tier I

Tier I action levels were developed to identify potential cleanup targets in areas where VOC contamination of groundwater exceeds 100 times the MCL (100 x MCL). These action levels identify groundwater contaminant sources that present a higher potential risk to surface water quality that should potentially be addressed through an accelerated action. If Tier I action levels are exceeded, an evaluation is required to determine if remedial or management action is necessary to prevent the highly contaminated (i.e., contaminant concentrations exceeding 100 x MCLs) groundwater from reaching surface water (the evaluation process is described in Section 4.1). This report represents the first phase of this evaluation.

Where action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination. Reference needed

23 313

resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of Appendix B. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. These wells are located at or near the boundaries of the composite VOC plumes shown in Figure 3-1, as described in Section 4.2. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	10692
10194	4087
1986	B206989
1386	

24314

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan (IMP). The document will incorporate two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document will also describe recent changes to the groundwater monitoring network.

The IMP will list the wells with their appropriate regulatory driver, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, until changes proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water quality through groundwater transport of leached contaminants. ~~As there are too many~~ variables to ~~accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils at~~ RFETS, the ~~Tier I action levels, are the same as Tier I action levels for the corresponding~~

2d TP
25315

It is currently not possible to accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils. The proposal that is out for public comment between 9/1 - 10/4/96 is that the action levels for inorganic contaminants in subsurface soil be the same as action levels for the corresponding contaminants in surface soil. These action levels are human-health risk based for the appropriate land-use receptor (office worker or open-space recreational user.)

~~contaminants in surface soil. These action levels are human-health risk-based for the appropriate receptor (office work or open-space recreational user), and are conservative since future land use scenarios do not include contact with subsurface soil.~~

Suggest including in 1st para.

Action levels for VOCs in subsurface soils were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to determine the equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Subsurface soil contaminant levels that would be protective of groundwater to Tier I action levels of 100 x MCLs were then calculated. These action levels for subsurface soils and are provided in Table 4 of Appendix B.

Tier I action levels for radionuclides in subsurface soils ~~are the same as applied as Tier I action levels for radionuclides in surface soils. with~~ the total dose from multiple radionuclides is calculated by the sum-of-ratios method. ~~These action levels~~ are the more conservative of:

- An annual radiation dose limit of 15 mrem for the appropriate land use receptor, or
- An annual radiation dose limit of 85 mrem for a hypothetical future resident assuming failure of passive control measures.

When multiple radionuclides are present,

Additional subsurface soil may need to be remediated or managed to protect surface water quality or ecological resources. These additional sites will be determined on a case-by-case basis.

Tier II action levels for radionuclides in subsurface soils are an annual radiation dose limit of 15 mrem for a hypothetical future resident.

3.4 Surface Soils

Surface soils are defined as the upper six inches of soil. Tier I action levels for non-radionuclides are human-health risk-based (carcinogenic risk equal to 10^{-4} and/or a HI of 1) for the appropriate land use receptor. In the industrial use area, action levels are based on office worker exposure as defined in the PPRG document. For the buffer zone area, action levels are based on open space recreational user exposure as defined in the PPRG document.

Tier II action levels for non-radionuclides are human-health risk-based (carcinogenic risk equals 10^{-6} and/or HI of 1) for the appropriate land use receptor.

Action levels for radionuclides in surface soil are the same as described above for subsurface soils.

Additional surface soil may need to be remediated or managed to protect surface water quality via runoff or ecological resources. These additional sites will be determined on a case-by-case basis.

318
~~28~~

4.0 GROUNDWATER CONTAMINANT PLUMES AND REMEDIATION

4.1 IDENTIFICATION

The VOC-contaminated groundwater plumes at RFETS have the most potential to impact surface water or to migrate offsite as the mobility of VOCs in groundwater far exceeds the mobility of metals and radionuclides. These plumes were defined on the basis of the exceedances of the Tier II action levels and are shown on Figure 3-1. Tier I action levels were compared against all groundwater data to locate areas of highly contaminated groundwater. These areas were plotted and are shown on Figure 4-1 along with proposed locations of the conceptual groundwater actions.

The probable sources of the VOC contaminated groundwater plumes were identified using the available data and process knowledge. ~~The flow diagram (see figure 4-2) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should~~ be targeted ~~for remedial action.~~

discuss

The IGD, RFCA (currently under prep) will describe the method used to determine if remedial or mngmt action approp.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed Tier I action levels. In addition, there are several plumes and areas of interest where contaminant concentrations do not exceed Tier I action levels, or are of very limited extent, but that are of interest due their potential to impact surface water above RFCA action levels, or due to their contaminant concentrations. The groundwater contaminant plumes with VOC concentrations exceeding Tier I action levels are: (1) 881 Hillside Drum Storage Area Plume, (2) Mound Plume, (3) 903 Pad and Ryan's Pit Plume, (4) Carbon Tetrachloride Spill Plume, (5) East Trenches Area Plume, and (6) IA Plume. Additional plumes discussed that do not exceed the Tier I action levels, but may have the potential to impact surface water, include those at the Present Landfill, Solar Ponds, and the ~~Property Utilization and Disposal~~ (PU&D) Yard.

The 903 Pad and Ryan's Pit Plume, the Mound Plume, and the East Trenches Plume are part of a large composite plume on the east side of RFETS. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

24 319

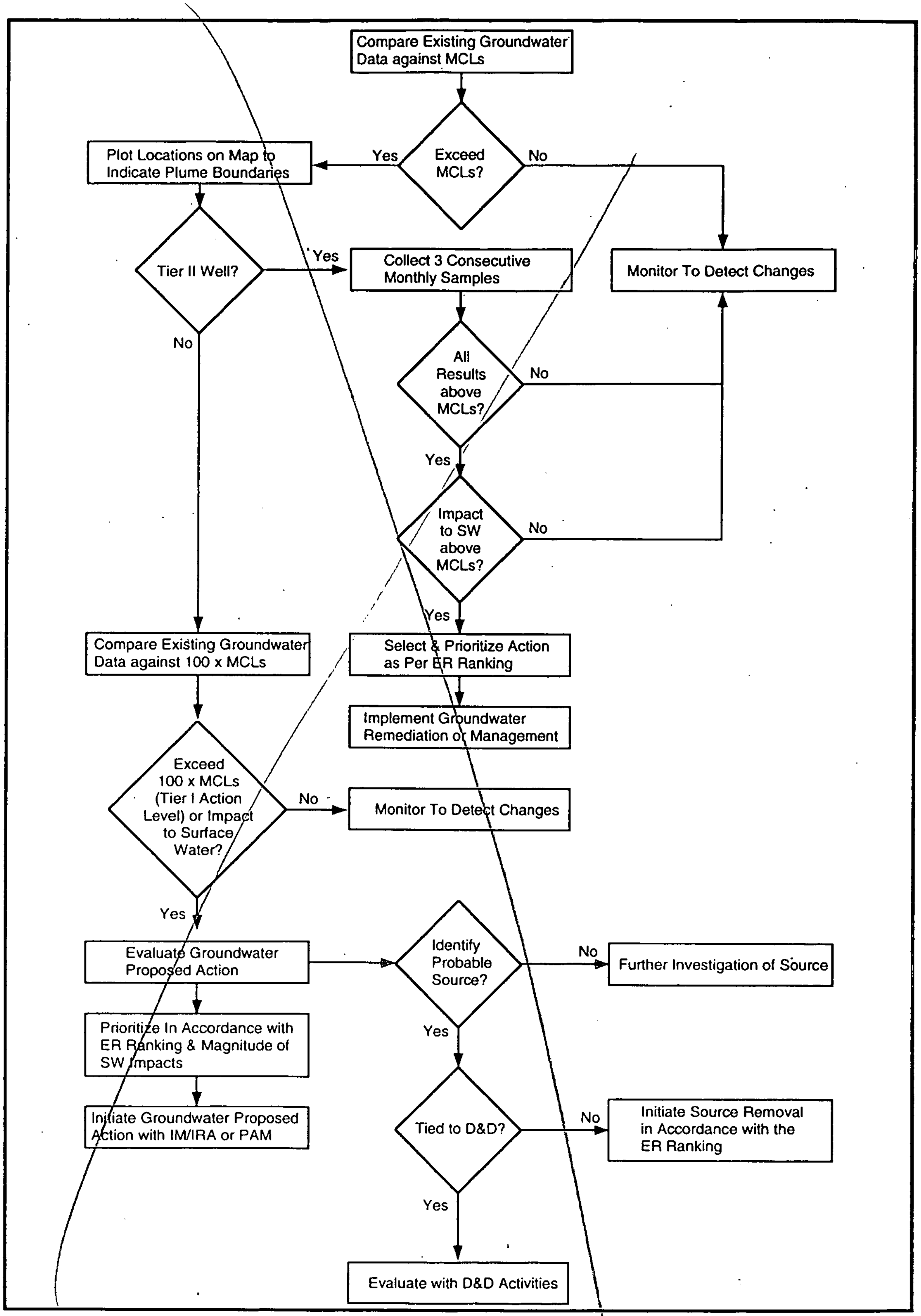

Figure 4-2 Flow Diagram

320

4.2 DESCRIPTIONS OF CONTAMINATED GROUNDWATER PLUMES

The extent of contaminated groundwater plumes in RFETS groundwater is not rapidly changing (see Section 2.0). The contaminated groundwater plumes are described below with much of the data derived from the relevant RFI/RI reports, data summaries, and the Hydrogeologic Characterization Report (EG&G 1995b).

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as indicated by the fact that hotspots removed in 1994 from this location had elevated plutonium levels (DOE 1995a).

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek (Figure 4.2.1-1). The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

At the 881 Hillside, groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (DOE 1994a).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are typically the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

3D1

alluvium. The bedrock topography and surficial deposit thickness can be used to extrapolate where groundwater flow may occur (DOE 1994a).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the dry climate and slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3 x 10^{-3} to 2 x 10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2 x 10^{-6} m^2/sec, approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992 (DOE 1994a).

Groundwater data collected since the installation of the French Drain suggests that the drain is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (DOE 1994a).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location (Figure 4.2.1-1). These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (Figure 4.2.1-1). The eastern source area underlies one of the radiological hot spots

333

removed in 1994. Both source areas could have been caused by leakage from individual drums (RMRS 1996b).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Figure 4.2.1-1 provides the distribution of contaminant concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996a).

4.2.2 Mound Site Plume

The Mound Site was used for as a disposal site for approximately 1,405 drums from April 1954 to September 1958. Drums contained depleted uranium, beryllium, lathe coolant (about 70% hydraulic oil and 30% carbon tetrachloride) and tetrachloroethene. Plutonium contaminated waste was also stored at this location, but plutonium levels were below detection limits. After it was noted that some of the drums were leaking, the drums were removed along with visibly stained soil. In addition, radioactive soils were removed at later dates. (Ref.)

334

The OU2 Phase II RFI/RI investigation identified acetone, methylene chloride, tetrachloroethene, trichloroethene and cis-1,3,-dichloropropene in the subsurface soils (DOE 1995b). Characterization results indicate increasing concentrations of tetrachloroethene and trichloroethene to a depth of 20 feet and decreasing concentrations below that depth. The recent Mound Site investigation (report in preparation) delineated the area of contamination as occurring near borehole 14295 and well 1987, comprising approximately 400 cubic yards. X

The Mound Site is located at the northern edge of the pediment where up to 12 feet of Rocky Flats Alluvium overlies fractured claystone of the Arapahoe Formation. The topography slopes steeply to the north away from the Mound Site towards the incised drainage of South Walnut Creek. The Arapahoe No. 1 Sandstone subcrops under the alluvium at the northwest corner of the Mound Site. This sandstone is truncated by the South Walnut Creek drainage and subcrops beneath the colluvium between the Mound Site and South Walnut Creek.

In the vicinity of the Mound Site, the Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses. The hill slope below the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation is covered with unconsolidated colluvium primarily composed of clay, or silty and/or sandy clay. Caliche is common in both alluvium and colluvium. There are numerous slump features are present on the hill slope.

Depth to groundwater is approximately 12 feet at the Mound Site (within the weathered bedrock), and unconsolidated materials are generally dry to much of the year. Saturated alluvium occurs in bedrock lows and paleoscours in the top of the bedrock. The groundwater flow appears to be primarily along the bedrock surface and is probably controlled by small channels incised into the bedrock surface. Groundwater flows to the north through the No. 1 Sandstone until it subcrops beneath the colluvium, indicated by a line of seeps along the slope towards South Walnut Creek. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration of precipitation or UHSU groundwater into the underlying unweathered claystone is limited (DOE 1995b).

335

Recharge occurs primarily through local infiltration of precipitation. The Central Avenue Ditch runs along the southern boundary of the Mound Site and probably also recharges the UHSU groundwater in this area. Discharge from the UHSU is mostly through seeps located where the water bearing units are truncated by the South Walnut Creek, and through evapotranspiration.

The groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound Site (Figure 4-1), to a point of discharge along the south bank of South Walnut Creek, upstream of the RFETS Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound Site area are suspected to be the source of the groundwater contamination. Trench T-1 could possibly contribute to this plume; however, dry wells between the Trench T-1 and the Mound Site indicate that the Mound Site is the primary source of the contaminated groundwater plume. The groundwater plume at the Mound Site apparently receives only minor contribution from VOC contamination at the 903 Pad. Wells in both the No. 1 Sandstone and alluvium upgradient of the Mound Site contain 0 to 2 ug/l total VOCs (DOE 1995b) (Figure 4.2.2-1). There is an east-west bedrock high located between the 903 Pad and Mound Site, near the south side of the Mound Site (Figure 4.2.2-2). VOC contaminated groundwater from the 903 Pad generally flows to the south of the Mound Site, on the south side of this bedrock high. X

Was this contribution defined

Thirty-five VOCs were detected in the contaminated groundwater at the Mound Site. All except tetrachloroethene, trichloroethene, cis-1,2-dichloroethene and vinyl chloride were below 100 ug/l. Tetrachloroethene was the predominant contaminant with the highest concentration of 13,000 ug/l found at the Mound Site. The maximum concentrations of cis-1,2-dichloroethene (214 ug/l) and trichloroethene (410 ug/l) were detected with the maximum tetrachloroethene value. Concentrations of these chemicals decrease towards South Walnut Creek. The maximum vinyl chloride concentration detected was 860 ug/l in a well along the South Walnut Creek drainage. The well is located over 500 feet from the source area, which indicates that this is a degradation product, not a primary constituent (DOE 1995b).

The contaminant plume is discharging through surface and subsurface seeps along the hillside, and along seeps on the south bank of South Walnut Creek. At seep SW059, groundwater containing low

336

levels of VOCs with trace amounts of radionuclides discharges at a rate of 0.5 gallons per minute, or less. The seep water is collected and treated at the Building 891 Combined Water Treatment Facility.

4.2.3 The 903 Pad and Ryan's Pit Plume

This contaminant plume has two closely spaced sources: (1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and (2) Ryan's Pit where VOCs were disposed of in a trench (Figure 4-1). The 903 Pad was characterized as part of the OU 2 Phase II ~~Resource Conservation and Recovery Act~~ (RCRA) RFI/RI ~~Facility Investigation/ Remedial Investigation~~ (DOE 1995b) and the following information was derived from that report.

The 903 Pad area was used to store drums that contained radioactively contaminated oils and ~~volatile organic compounds~~ (VOCs) from the summer of 1958 to January 1967. Approximately three ~~fourths~~ quarters of the drums contained plutonium-contaminated liquids while most of the remaining drums contained uranium-contaminated liquids. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were hydraulic oils, vacuum pump oils, trichloroethene, tetrachloroethene, silicone oils, and acetone still bottoms.

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium. From 1968 through 1969, some of the radiologically contaminated material was removed, the surrounding area was regraded, and much of the area was covered by clean road base and an asphalt cap.

Ryan's Pit, previously referred to as Trench T-2, is located approximately 150 feet south of the 903 Pad (Figure 4.2.2-1). The dimensions of the pit are approximately 20 feet long, 10 feet wide, and

337

five feet deep. The Pit was used as a waste disposal site from 1969 and 1971 for nonradioactive liquid chemical disposal. VOCs disposed at this location included tetrachloroethene, trichloroethene, and carbon tetrachloride. In addition to VOC disposal, paint thinner and small quantities of construction-related chemicals may also have been placed in Ryan's Pit. According to historical data, only the liquids themselves were put in the pit; their containers were either reused or disposed of in other areas.

Materials placed in the Pit were supposedly screened for radionuclide activity prior to disposal. However, field investigations conducted in 1987 through 1993 do not substantiate this claim. The contaminated soils were removed from this site and treated during the 1995 removal action at Ryan's Pit. Free phase tetrachloroethene and motor fuel constituents were found during this removal action, along with degraded drums and plutonium contaminated soils. Free phase DNAPLs are also suspected to exist underneath the 903 Pad as high concentrations of VOCs are present in the groundwater (greater than 1% of the chemical's solubility).

The 903 Pad is located on the flat surface at the southern edge of the pediment. A south facing hillside slopes downward from the 903 Pad to the SID and Woman Creek. Ryan's Pit is located on the hillside about 200 feet from the southern edge of the 903 Pad. In the 903 Pad area, the Rocky Flats Alluvium is 10 feet thick at the northwest corner of the Pad which is near a bedrock high, and 25 feet thick at the southeast corner which is within a bedrock channel. The 903 Pad is paved with asphalt, and artificial fill is present under the 903 Pad and covers a large area to the south and east of the Pad.

The Rocky Flats Alluvium is truncated by erosion and does not extend to ~~the~~ Ryan's Pit area. The Ryan's Pit ~~area~~ surficial deposits consist of reworked Rocky Flats Alluvium that has been transported down slope, along with other clay-rich colluvium deposits and fill material. Surficial deposits consist of colluvium between one and eight feet thick which is primarily clay, and silty or sandy clay. Caliche is common in both the alluvium and colluvium. Groundwater at Ryan's Pit is between 3 to 10 feet below ground surface. On the slope, there are numerous slump features, and a large scarp face is located between the 903 Pad and Ryan's Pit.

338

Bedrock in the 903 Pad and Ryan's Pit area is primarily composed of weathered claystone of the Arapahoe and Laramie Formations. In addition, the Arapahoe No. 1 Sandstone subcrops under the alluvium at the extreme northwest corner of the 903 Pad. This sandstone is continuous with the Arapahoe No. 1 Sandstone at the Mound Site, where it is truncated by the South Walnut Creek drainage. The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6×10^{-4} cm/sec. The geometric mean for the Araphoe No. 1 Sandstone hydraulic conductivity is 7×10^{-4} cm/sec. The geometric mean for unweathered bedrock is 8×10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited. (ref.)

Groundwater flow is complex and is primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thicknesses. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well-defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

haven't used this term before

A large bedrock low (paleoscour) extends from the 903 Pad east and passes directly south of the East? Northeast Trenches. This paleoscour is bounded by bedrock highs to the north and south. Near the 903 Pad, there is 20 to 25 feet of relief between the paleoscour and the northern bedrock high, and 5 to 10 feet of relief between the paleoscour and southern bedrock high (see Figure 4.2.2-1). The paleoscour directs groundwater flow to the east till it is truncated by the South Walnut Creek drainage where alluvial groundwater discharges into the head of a well-developed gully. Groundwater flow from the 903 Pad towards the SID and Woman Creek also occurs either by overtopping of the lower, southern bedrock high, or through breaks in the bedrock high. During dry periods, the bedrock highs restrict alluvial groundwater flow to the south and north. During wet periods, when the alluvial groundwater levels are very high, flow may overtop these barriers, primarily to the south. (refs.)

Groundwater flow in the colluvium follows north-south trending small paleochannels cut into the underlying bedrock claystone. One narrow paleochannel, approximately 150 to 300 feet wide,

339

extends from the 903 Pad south through ~~the~~ Ryan's Pit area (Figure 4.2.2-1). The areas surrounding these paleochannels is unsaturated. The southern extent of groundwater flow is not well defined due to lack of well control.

Recharge is primarily from infiltration of precipitation along with some recharge from ditches and other surface water features. Wells located to the west of the 903 Pad are generally dry as alluvial groundwater inflow from the west is restricted by the claystone bedrock high just west of the 903 Pad. Unconsolidated materials within the medial portion of the paleoscour tend to be saturated, with the extent of saturation greatest during the Spring. Groundwater flow occurs through the No. 1 Sandstone until it subcrops beneath the colluvium. Discharge is primarily to seeps located where the water bearing units are truncated by the South Walnut Creek drainage. All UHSU groundwater is discharged to seeps or into the colluvium.

The 903 Pad and Ryan's Pit Plume is defined as the lobe of contaminated groundwater that flows southward from these two source areas. This plume flows southward toward the SID and Woman Creek drainage. The lobe of contaminated groundwater which flows eastward from the 903 Pad is addressed as part of the East Trenches Plume (Figure 4.2.2-1).

Contaminated groundwater in the 903 Pad and Ryan's Pit area is primarily confined to the alluvium and colluvium. Total VOC concentrations for the Arapahoe No. 1 Sandstone are approximately 2,500 ug/l adjacent to the west edge of the 903 Pad with concentrations at other locations less than 2 ug/l or non-detects. Fifty-seven VOCs were detected in UHSU groundwater for this plume. However, the primary contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene. The southern component of the contaminant plume derived from the 903 Pad contains total VOCs in the 5,000 ug/l range near the Pad, diminishing to 1,500 to 2,000 ug/l range upgradient of Ryan's Pit. Downgradient of Ryan's Pit, the total VOC concentration in groundwater ranges from 57,000 ug/l near the Pit to 5 ug/l near the distal end of the plume. The total VOC concentration in contaminated groundwater from the 903 Pad which does not also flow through the Ryan's Pit source is also estimated at 5 ug/l when it nears Woman Creek drainage. (? refs.)

The highest concentrations of many VOC contaminants in the former OU 2 area are located within this plume. The highest concentration of tetrachloroethene (150,000 ug/l) was detected immediately

340

downgradient of Ryan's Pit and occurred with 1,1-dichloroethene at 380 ug/l. A well installed through the center of the 903 Pad contained concentrations of carbon tetrachloride in groundwater at 20,000 ug/l, chloroform at 39,000 ug/l and methylene chloride at 35,000 ug/l. A well installed though the northeast corner of the Pad detected tetrachloroethene at 14,000 ug/l. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although wells with VOC concentrations exceeding Tier I levels have been observed within the plume away from these sources (Figure 4.2.2-1).

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the ~~South Interceptor Ditch~~ SID and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit plume ~~will~~ may reduce the potential risk to the environment posed by uncontrolled releases to surface water. (can we reference this) no reference except this

4.2.4 Carbon Tetrachloride Spill Plume

The Carbon Tetrachloride Spill (IHSS 118.1) is located due north of Building 776 and east of Building 730 (Figure 4.2.4-1). While there are other IHSSs that overlap IHSS 118.1, (IHSSs 121-Tank 9, 121-Tank 10, 131, and 144[N]), the contamination in the area is primarily related to the carbon tetrachloride spills.

IHSS 118.1 is the site where an underground, 5,000-gallon, carbon tetrachloride steel storage tank and the associated piping were formerly located. The tank was installed prior to 1970, and probably began leaking shortly after installation. Numerous spills occurred before 1970, some between 100 to 200 gallons (DOE 1992b). The tank ultimately failed in June 1981, releasing carbon tetrachloride into the containment structure. The carbon tetrachloride was pumped from the containment structure to the surrounding ground surface, and the tank was removed along with a limited amount of soil surrounding the tank. The surrounding concrete containment structure was probably removed at this time also, but this has not been verified.

The surrounding area has numerous underground and overhead utilities and structures. These include clay sanitary sewer lines, electrical lines, tunnels between buildings, process waste lines and process waste tanks. Immediately east and partially overlapping this site is a group of four process waste tanks oriented east-west, tank groups T-9 and T-10. T-9 consists of two 22,500 gallon underground concrete storage tanks. T-10 consists of two 4,500 gallon concrete underground tanks. Both sets of tanks were installed in 1955, but are no longer used as process waste tanks. T-9 is currently being utilized as a plenum deluge catch tank for Building 776. No releases from either set has been documented (DOE 1995c).

Due to past construction activities in this area, the material overlying the claystone bedrock is predominantly fill material, probably derived from the Rocky Flats Alluvium, along with some remaining undisturbed Rocky Flats Alluvium. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. The geometric mean for the hydraulic conductivity of the Rocky Flats Alluvium is estimated at 2.06×10^{-4} cm/sec. (ref.)

The recent IA investigation found free product in the subsurface soil and groundwater related to IHSS 118.1. All four of the soil borings drilled around T-9 and T-10 intercepted free-phase carbon tetrachloride (DOE 1995c). When a water sample was collected at this location, the liquid separated into two distinct phases. Other VOCs may be present, but the high concentrations of carbon tetrachloride may mask their detection. The top of bedrock surface prior to construction of Building 771 sloped to the northeast. Excavation during construction of this building altered this surface as the claystone surface was found 10 feet or more below where it was expected during the recent field investigations. Excavation may have either increased the slope of the bedrock surface, or created a bedrock low closed by the building. The bedrock in this area is claystone which limits vertical migration of the carbon tetrachloride. As carbon tetrachloride sinks to the lowest possible depth, the bedrock surface, building footing drains, and subsurface structures probably control the extent of the free-product plume and much of the dissolved phase portion of the contaminated groundwater plume.

Groundwater flow in this area is to the northeast towards Buildings 771 and 774 where there are known footing drains (Figure 4.2.4-2). Buildings 701 and 730 are not believed to have subsurface structures. Monitoring wells in the area contain carbon tetrachloride ~~in the groundwater~~ which indicates that a dissolved plume is present in the groundwater. In addition to carbon tetrachloride, several other VOCs are present in the groundwater plume; primarily 1,1-dichlorethene, chloroform and acetone (Figure 4.2.4-1). This contaminated groundwater plume may eventually reach the North Walnut Creek drainage, especially after removal of the surrounding buildings.

Carbon tetrachloride and trichloroethene concentrations have been detected in a downgradient well completed in the Arapahoe No. 1 Sandstone at the western edge of the Solar Ponds, due east of IHSS 118.1. Carbon tetrachloride concentrations range from approximately 1,000 to 21,000 ug/l and the trichloroethene concentrations range from 2,000 to 8,000 ug/l. The concentrations fluctuate greatly over time, but there is a general decreasing trend. The carbon tetrachloride spill is believed to be the source of this contamination and, if true, this would indicate that there is some eastward movement of the dissolved phase of the plume. The decreasing trend over time may be a result of the VOCs originally in the vadose zone at the time of the spill, flushing out of the upper soil horizon and/or settling to the bedrock surface, where there is less contact with groundwater. It is also possible that the Solar Ponds VOC contaminantion is related to a still unidentified contaminant source. (ref.)

The Solar Ponds area is in hydraulic connection with subcropping Arapahoe No. 1 Sandstone which could act as a conduit to surface water for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

4.2.5 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area, primarily associated with the trenches on the north side of the East Access Road. These trenches are known as the Northeast Trenches and include Trenches T-3, T-4, T-10 and T-11. Upgradient wells indicate a component of the contaminated groundwater in this area is derived from the VOC contamination in the 903 Pad (see Section 4.2.3 and Figure 4.2.2-1). However, the VOC concentrations in groundwater increase over 100 times after the groundwater passes through Trenches T-3 (IHSS 110) and T-4 (IHSS 111.1), indicating a VOC source is present. (ref.)

Trench T-3 is located approximately 300 feet north of the East Access Road and immediately west of Trench T-4. Trench T-3 is approximately 134 feet long, 20 feet wide and 10 feet deep (DOE 1992b). Trench T-4 is approximately 110 feet long, 15 feet wide, and 10 feet deep (RMRS 1996c). The trenches were reportedly used sometime between 1954 to 1968 for disposal of sanitary sewage sludge, potentially contaminated with uranium and plutonium, and flattened empty drums contaminated with uranium. The trenches are also known to contain DNAPLs, crushed drums, and other miscellaneous waste. Except for the debris found in the trenches, activities of the trench material are below the RFETS soil put-back levels.

Trench T-3 and T-4 are located at the northern edge of the pediment where up to 18 feet of Rocky Flats Alluvium overlies fractured claystone and the No. 1 Sandstone of the Arapahoe Formation. Beyond the pediment boundary, the topography slopes steeply to the north towards South Walnut Creek. Both the alluvium and the Arapahoe No. 1 Sandstone are truncated by the South Walnut Creek drainage. Both of these trenches have been excavated as a source removal action in 1996.

The unconsolidated surficial deposits consist of the Rocky Flats Alluvium and artificial fill in the trenches and are generally dry. The Rocky Flats Alluvium consists of beds and lenses of poorly to moderately sorted clayey and silty gravels and sands interbedded with clay and silty lenses or beds. Thickness of the alluvium is approximately 18 feet at Trench T-4 and 16 feet at Trench T-3. Below the outcrop of the contact between the Rocky Flats Alluvium and the underlying Arapahoe Formation, the slope is covered with unconsolidated colluvium primarily composed of clay, or silty and sandy clay. Caliche is common in both alluvium and colluvium. On the slope, there are numerous slump features.

Underlying the alluvium to the north of the trenches is the continuation of the claystone bedrock high from the 903 Pad area. The center of the associated paleoscour runs beneath Trenches T-11 and T-10 to the south of Trenches T-3 and T-4 (Figure 4.2.2-2). This feature directs the surficial groundwater flow to the east, away from South Walnut Creek. However, the Arapahoe No. 1 Sandstone subcrops beneath the eastern portion of trench T-3 and most of Trench T-4. This fluvial sandstone is incised into the surrounding bedrock claystone and consists of sandstone, clayey sandstone, and silty sandstone. The channel of the Arapahoe Formation No. 1 Sandstone is approximately 40 feet thick and mostly saturated. Groundwater flow is generally unconfined, and flow within the channel is northward towards South Walnut Creek (EG&G 1995c). The sandstone subcrops beneath the colluvium between the trenches and South Walnut Creek at a spring and seep complex.

The geometric mean for the Rocky Flats Alluvium hydraulic conductivity is 6 x 10^{-4} cm/sec. The geometric mean for the Arapahoe No. 1 Sandstone hydraulic conductivity is 7 x 10^{-4} cm/sec and the geometric mean for unweathered bedrock is 8 x 10^{-8} cm/sec. Infiltration into the underlying unweathered claystone is limited.

Recharge of the Rocky Flats Alluvium is primarily through infiltration of precipitation, and upgradient flow from within the paleoscour. Recharge to the No. 1 Sandstone is from infiltration of precipitation through the surficial deposits, and some flow from upgradient. Discharge is primarily to seeps and springs located where the water bearing units are truncated by South Walnut Creek, and by evapotranspiration.

Contaminated groundwater occurs in the alluvium and in the No. 1 Sandstone that is in hydraulic connection with the alluvium. While 27 VOCs were detected within the UHSU groundwater, the majority were detected at concentrations below 100 ug/l. The major contaminants are trichloroethene (maximum value of 94,000 ug/l), carbon tetrachloride (maximum value of 4,500 ug/l), and tetrachloroethene (maximum value of 1,000 ug/l). During the Soil Vapor Extraction Pilot Test Project, stratified water/NAPL samples were collected and analyzed from Trench T-3. These samples contained high levels of VOCs, up to 37,000,000 ug/l for tetrachloroethene along with semivolatiles, petroleum compounds, and uranium-238 at concentrations up to 3,240 pCi/g (DOE 1995b). In addition, borehole samples collected from T-4 contained 12,000 ug/kg tetrachloroethene and 1,000 ug/kg trichloroethene.

The downgradient boundary of the contaminant plume is located at a spring and seep complex on the south bank of South Walnut Creek, above Ponds B-1 and B-2, where the No. 1 Sandstone subcrops. Concentrations of VOCs above 100 x MCLs have been detected by a recent sampling program conducted at the seep complex. There may be potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut

346

Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

A lobe of this contaminant plume extends to the east of the East Trenches area along the paleoscour cut into the bedrock surface. However, contaminated groundwater has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored ensure that contaminated groundwater from this lobe does not impact surface water.

4.2.6 IA Plume

Several sources in the IA contribute trichloroethene, tetrachloroethene, and carbon tetrachloride to the contaminated groundwater plume in the IA. The plume is defined based on a small number of wells, and is thought to be principally confined to the east central side of the plant. It is not clear whether it is a large coalesced plume, or discrete areas of contaminated groundwater closely associated with individual source areas. The contaminated groundwater plume is outside of the fenced portion of the protected area (PA) and extends downgradient towards the central portion of the IA. Primary contaminant sources are described below and shown on Figure 4.2.4-1.

IHSSs 117.1 was used as a general storage yard from before 1959 to the early 1970s and is located northeast of Building 551 (DOE, 1992b). The IA soil gas investigations found elevated soil gas levels of tetrachloroethene (2,200 ug/l), with less than 20 ug/l concentrations of trichloroethene and carbon tetrachloride and cis-1,2-dichloroethene. Elevated benzene, toluene, ethylbenzene and xylene (BTEX) levels are present in the southwest edge of the IHSS (OU 13 data summary). Check!

IHSS 117.2, located east of Building 551, was used as a chemical storage site from prior to 1971 until approximately 1988. This site was used to store acids, oils, soaps, solvents, and beryllium scrap metal. Minor leaks and spills occurred (DOE 1992b). The IA soil gas investigations determined the presence of elevated levels of 1,1-dichlorethene (2,700 ug/l) along with concentrations above 100 ug/l for vinyl chloride, cis-1,2 dichloroethene, trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Elevated concentrations of BTEX are also present (DOE 1995d).

There have been numerous carbon tetrachloride spills within Building 776, resulting in suspected under building contamination. This building may be the source of low level concentrations of carbon tetrachloride in groundwater on the eastern side of the plantsite.

The IHSS 157.1 is adjacent to the Building 442 Laundry. Very low level concentrations (below 5 ug/l) of tetrachloroethene (PCE) were detected in soil gas samples from this location (DOE 1995d).

IHSS 158 is an area where waste boxes were staged and loaded onto rail cars. This area is considered a radioactive site, and is located north of Building 551. Soil gas surveys found concentrations above 100 ug/l for vinyl chloride, toluene, and BTEX at this location (DOE 1995d).

IHSS 160 is a parking lot on the west side of Building 444. Drummed and boxed wastes were stored at this location prior to paving, and leaked (HRR). The soil gas survey detected tetrachloroethene at 99 ug/l at this location. Concentrations less than 10 ug/l each of toluene, acetone, and benzene are also present (DOE 1995e).

IHSS 171 is a training area for fire department personnel. In the past, diesel, gasoline and possibly waste solvents were ignited for fire fighting training purposes. The area is currently in use, and a metal tree is used for burning propane for training. Large volumes of water are used during training which may tend to accelerate migration of any contaminant plume. As expected, large concentrations of BTEX are present in the subsurface soils. Soil gas samples do not indicate high concentrations of VOCs. However, during drilling of a geoprobe hole in this IHSS, the rod came up coated with a brown liquid. Unfortunately, a sample could not be collected for analysis. It is possible that free product VOC does exist at this location (DOE 1995d).

The hydrogeology of the IA has not been as extensively studied as other areas at RFETS. The Hydrogeologic Characterization Report (EG&G 1995) was the primary source for the following hydrogeologic information. The IA is located on a pediment capped by the Rocky Flats Alluvium. The pediment has been eroded at the sides to expose the underlying claystone of the Arapahoe and Laramie Formations. The Rocky Flats Alluvium consists of unconsolidated gravels, sands and clays with discontinuous lenses of clay silt and sand. Fill material is abundant and usually consists of

reworked Rocky Flats Alluvium. The geometric mean for the hydraulic conductivity all of RFETS Rocky Flats Alluvium is 2.06×10^{-4} cm/sec.

Groundwater occurs under unconfined conditions and flow is generally controlled by the topography of the underlying bedrock surface. Groundwater flow direction in the IA is generally eastward, with groundwater in the northern sections flowing to the northeast (Figure 4.2.4-2). Several building footing drain systems locally impact groundwater flow. Small bedrock channels are known to occur which direct the groundwater flow.

The IA groundwater plume is greatly influenced by the RFETS infrastructure. Groundwater recharge in the IA is from upgradient flow, infiltration of precipitation and substantial water losses from sewers and water-supply pipelines. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

The saturated thickness in the IA is typically 5 feet or less, with the greatest saturated thicknesses in the western part of the IA, decreasing to less than 5 feet in the eastern half of the IA. There are many unsaturated zones, particularly in the eastern half of the IA. These unsaturated areas are controlled by the bedrock, with bedrock highs generally dry. The decrease in saturated thickness in the eastern half of the IA may be caused by impermeable areas, such as parking lots and buildings, which greatly limit infiltration. In addition, areas of high local recharge may be created adjacent to the impermeable areas. Approximately 190 of 438 acres within the IA are covered by impermeable material. As a result, a greater amount of storm water runoff is channeled to permeable areas and may account for the large variations in saturated thickness.

Discharge from the IA is probably primarily to building footing drains, engineered structures such as the OU 1 French Drain and the Solar Ponds Interceptor Trench System, and potentially to seeps at the boundary of the IA. Both the Interceptor Trench and OU 1 French Drain have removed sufficient water from the surficial deposits to cause these to be locally unsaturated. Infiltration of groundwater into the underlying bedrock is generally limited due to the low hydraulic conductivity of the unweathered bedrock.

The IA groundwater contaminant plume extent is also controlled by interception of the plume by building footing drains and by the increased permeability and hydraulic conductivity through buried utility corridors. Full understanding of the migration of this plume depends on knowing how the various buildings, utility corridors, and sources interact. Unfortunately, there is insufficient knowledge of these factors to completely determine the configuration of this plume.

Figure 4.2.4-2 shows the average concentrations of VOC contaminants in the groundwater wells, and the probable contaminant sources. Treatment of contaminated groundwater within the IA does not appear to be necessary to protect surface water, because of the limited potential for migration. However, ongoing monitoring and evaluation of the groundwater will continue, to detect any movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand, migrate significantly or become a threat to surface water. Actions such as removal of buildings, removal of subsurface structures, and placing impermeable caps over areas must be examined to determine whether these will increase the movement of the contaminated groundwater plume. Controls may be required if increased groundwater contaminant plume movement results from these actions.

4.2.7 Additional Plumes and Areas of Contaminated Groundwater

There are several areas where there are sporadic occurrences of VOC-contaminated groundwater, or where there are contaminant plumes with VOC concentrations less than 100 x MCLs. Contaminant plumes in the Present Landfill and Solar Ponds groundwater do not contain VOC concentrations greater than 100 x MCLs. However, these plumes are of interest because they are associated with RCRA units. In addition, a widespread but diffuse VOC plume is located near the PU&D Yard west of the Present Landfill. The setting and status of many of these plumes and occurrences are discussed below.

Present Landfill Plume

Operation of the Present Landfill (IHSS 114) for disposal of nonradioactive solid waste began in 1968 and will continue until the new landfill opens, or another method of waste disposal is available. The landfill covers an area of approximately 27 acres (Figure 1-1). The total volume of landfill

349

material is approximately 415,000 cubic yards and consists of approximately 291,000 cubic yards of waste and 124,000 cubic yards of soil cover.

Elevated tritium and strontium concentrations were detected in leachate draining from the landfill in 1973. To control the migration of contaminants, interim response actions were taken. Interim response activities included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill (West Landfill Pond and East Landfill Pond), a subsurface intercept system for diverting groundwater around the landfill and a subsurface leachate collection system. Between 1977 and 1981, the leachate collection and groundwater intercept system were buried beneath waste during landfill expansion. The lateral expansion of waste placement resulted in waste being located beyond the extent of the subsurface drains to the north and south. In 1982, two soil bentonite slurry walls were constructed to prevent groundwater migration into the expanded landfill area.

Leachate is a product of natural biodegradation, infiltration, precipitation, and migration of groundwater through waste. Approximately 5,756,000 gallons of leachate are present in landfill debris within the intercept system and above the unweathered claystone bedrock which is considered the underlying confining unit. The saturated thickness of surficial materials is greatest near the center of the landfill which suggests that recharge may be occurring by groundwater flow under or through the north groundwater intercept system. Groundwater inflow may be occurring where the groundwater intercept system is not keyed into bedrock. Although an area of the south slurry wall is also not keyed into bedrock, well data indicates that it is effective in diverting groundwater.

During the Phase I RI/RFI investigation, 38 discrete groundwater samples were taken. In addition, 1990-1993 monitoring well data from 52 wells were used as the basis for determination of preliminary contaminants of concern. Groundwater in the UHSU at OU 7 contained metals, radionuclides, organic constituents and nitrates at concentrations higher than background (EG&G 1994).

The highest concentration of chlorinated hydrocarbons occurred in groundwater upgradient of the landfill. VOC contamination upgradient is composed entirely of chlorinated hydrocarbons. In contrast, average BTEX concentrations were highest in leachate collected from within the landfill. The BTEX compounds were not detected in upgradient groundwater. Different types of VOC contamination are presented within the landfill and upgradient (southwest) of the landfill, suggesting that a distinct source of VOC contamination is present upgradient of the landfill.

Do we want to discuss the seep collection system

350

Two separate groundwater plumes exist in the vicinity of the Present Landfill (Figure 3-1). The plume from the landfill source is located west of the landfill and is migrating down the No Name Gulch drainage. A second plume from an unknown source upgradient of the landfill is located in the groundwater south of the current landfill. The second plume is diverted to the south of the southern slurry wall. A groundwater divide is located approximately 500 feet south of the southern slurry wall.

Antimony, iron, manganese, tritium, uranium-238, chloromethane, ethylbenzene, and vinyl chloride concentrations in the groundwater from the landfill plume exceed the Groundwater Tier II Action Levels. Because of the proximity to No Name Gulch, monitoring and further evaluation are required.

Solar Ponds Nitrate Plume

The Solar Evaporation Ponds (SEPs) consists of five surface water impoundments (Figure 1-1). From 1953 to 1986, these were used to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. The materials placed into the SEPs included radioactively contaminated aluminum scrap metal, alcohol wash solutions, drums of waste radiography solutions, leachate from the Present Landfill, treated sanitary effluent, groundwater intercepted from the Interceptor Trench System (ITS), salt water solutions, wash water from the decontamination of production personnel, cyanide wastes, acid wastes and miscellaneous other compounds (DOE 1995f). Removal of pond sludge began in June 1985 and was completed for all SEPs by January 1995.

The SEPs are on the eastern boundary of the pediment capped by the Rocky Flats Alluvium. Streams have eroded the pediment to the north and south with topographic relief of 50 to 100 feet. Much of the surficial deposits have been disturbed by construction of the SEPs, the ITS, nearby buildings and other infrastructure, however, borehole logs suggest that undisturbed Rocky Flats Alluvium often occurs below the disturbed ground.

Thickness of the unconsolidated material ranges from 0 to 25 feet, and averages about 10 feet. The Rocky Flats Alluvium overlies over the erosional bedrock surface and consist of poorly to

351

moderately sorted gravel, sand, silt and clay with boulder to pebble size clasts derived from the nearby Front Range. Artificial fill was used as for road grade fill, berm construction, recontouring around engineered structures, and to fill in lows for the surface impoundments. Fill consisted of reworked Rocky Flats Alluvium with imported offsite materials including crushed rock, plus sandy clay and gravel with fragments of concrete rubble. The Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and fill materials. Claystone is the predominant subcropping lithology, but the No. 1 Sandstone subcrops in the vicinity of South Walnut Creek.

The shallow, unconfined groundwater occurs in unconsolidated surficial material and fractures in the underlying bedrock and the potentiometric surface generally mimics the surface topography. General flow direction is to the northeast under the SEPs. A bedrock high trending east-west under the SEPs diverts the northern flow to the north-northeast towards North Walnut Creek, and the southern flow to the east-southeast towards South Walnut Creek. Unsaturated areas are present over a large part of the area, in part due to the ITS. However, unsaturated areas to the south and east are not impacted by the ITS. The saturated thickness varies from 0 to 5 feet over most of the area, and is thinner along topographic highs, or on slopes where there are thin alluvium or colluvium deposits. Along North and South Walnut Creek, the saturated interval can be as much as 10 feet thick.

Hydraulic conductivity for the Rocky Flats Alluvium in this area is around 10^{-5} cm/sec. No data were given for the fill material. The hydraulic conductivities for the subcropping bedrock claystone ranges from 10^{-7} to 10^{-9} cm/sec. The hydraulic conductivities for the subcropping bedrock sandstone ranges from 10^{-5} to 10^{-6} cm/sec (DOE 1996b).

A large UHSU nitrate plume extends north and east from the Solar Ponds to the North Walnut Creek drainage above Pond A-1. Three wells with uranium concentrations above background are also found in the contaminated groundwater plume. A lobe of this nitrate plume extends to the southwest for a short distance. While the primary nitrate source has been removed for several years, this contaminant plume still contains nitrates at concentrations above 100 x MCLs. However, samples taken from the ITS show that nitrate concentrations within the plume are decreasing. For November 1993, nitrate concentrations were 366 mg/l, and in June 1995, nitrate concentrations were 277 mg/l (RMRS 1996d). The ITS was installed to intercept contaminants and capture the nitrate plume. It was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gallons

of water per year, but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE 1994b).

VOCs are present in the groundwater at the western edge of the Solar Ponds Area and are most likely related to the carbon tetrachloride spill from IHSS 118.1 discussed earlier (Section 4.2.4.) Carbon tetrachloride is present at well P210189 at concentrations of 4,700 ug/l, along with tetrachloroethene at 1981 ug/l and trichloroethene at 2,200 ug/l. This well is completed through 4 feet of silty sandstone at a depth of 31 feet which is believed to be the Arapahoe No. 1 Sandstone. This subcropping sandstone could act as a conduit for the dissolved phase carbon tetrachloride plume. The extent of the contamination in the sandstone is unknown, and a limited investigation is proposed to determine the extent of contamination and whether there is a pathway to surface water.

PU&D Yard Plume

The PU&D Yard has been used since 1974 to store drums, cargo boxes and dumpsters. The PU&D Yard is located northwest of the industrial area in an area approximately 225 feet by 830 feet (Figure 1-1). Materials known to have been stored there include spent batteries, metal shavings coated with lathe coolant, and drums of spent solvents such as paint thinners and waste oils. Drummed hazardous material was also transferred in this area. Subsurface contamination may exist from historical spills associated with past hazardous material transfer operations and storage at the site. Releases of battery acids and leaks from dumpsters and drums of spent solvents and waste oils have been reported.

The PU&D storage yard is underlain by the Rocky Flats alluvium which is approximately 25-30 feet thick in the vicinity. The alluvium is underlain by Arapahoe Formation claystone. Groundwater in this area flows to the east through the UHSU materials, mimicking the surface topography.

Recent soil gas investigations have verified the presence of volatile organic compounds immediately outside the eastern boundary of the PU&D storage yard. Organics,,metals, and radionuclides have also been detected in surface soils (DOE 1995g). However, there are no subsurface samples of the soil and groundwater from this area.

353

An area of poorly defined, contaminated groundwater, with VOC concentrations slightly above the MCLs, is located downgradient of the PU&D Yard, and upgradient and to the south of the Present Landfill. Further investigation is required to identify the source or determine whether there is potential for impact to surface water quality.

Other 881 Hillside Groundwater Contamination

There are several one-time detects of VOCs in groundwater along the 881 Hillside (Figure 1-1). These do not seem to be related to a source, and may be more related to the problems of detecting very low levels of VOCs. In addition, there are two areas where contaminated groundwater has been identified, but where no action is required. Immediately adjacent to Building 881, there are sporadic detects of low concentrations of chlorinated solvents in groundwater. This suggests that several small point sources may exist in this area that are related to building operations.

The UHSU monitoring wells within the IHSS 119.2 drum storage area are dry or do not detect VOCs. However, there are infrequent detects of VOCs in groundwater sampled from two wells located within the drainage downgradient from IHSS 119.2. The source of these sporadic VOC detections may be the volatile plume derived from the 903 Pad.

In addition to the VOC contamination, the 881 Hillside groundwater contains selenium and vanadium at above background levels. Neither of these elements is a documented RFETS waste, nor requires remedial action to protect surface water.

Old or Original ?

Old Landfill Groundwater Contamination

Show location on Fig 1-1

The Old Landfill was in operation from 1952 to 1968 and was used to dispose of approximately 2 million cubic feet of miscellaneous RFETS waste (Figure 1-1). Accurate and verifiable records of the material placed into this landfill are not available, but all of the waste material was considered non-hazardous at the time. However, paint, solvents, paint thinners, oil, pesticides, and cleaning agents were placed in the landfill as these were not considered hazardous in 1968. The landfill also received some beryllium, depleted uranium, and used graphite. The Old Landfill does not have a

354

liner, but the underlying unweathered claystone has a permeability of 10^{-5} to 10^{-7} cm/sec. The landfill was closed with a soil cover sometime after 1968 and prior to 1980 (DOE 1996c).

Groundwater occurs in the surficial deposits, primarily in the landfill material and alluvium. Many groundwater samples were collected during the OU5 RFI/RI investigation from wells, hydropunch samples from boreholes, and one-time samples from well points. The groundwater COCs identified for the Old Landfill are barium, manganese and radium, however, these do not correlate well with the waste known to be disposed at this site. Two small areas of VOC contaminated groundwater in are present in the Old Landfill area. One area is associated with a subsurface soil gas anomaly, the other is upgradient of the Old Landfill, probably related to the IA (Section 4.2.6).

The OU5 RFI/RI soil gas investigation (DOE 1996c) located two, small, subsurface soil gas anomalies at the Old Landfill. One area is approximately 50 feet by 50 feet and associated soil gas samples contain trichloroethene and 1,1,1-trichloroethene, and the other is about 64 feet by 64 feet and associated soil gas samples contain tetrachloroethene and trichloroethene. Trichloroethene (maximum concentration of 19 ug/l) is sporadically detected in groundwater at one well associated with the larger anomaly. There are no VOCs in groundwater associated with the other anomaly.

One well upgradient of the Old Landfill (P416789) has had three historical detects of TCE. This well is probably detecting contaminated groundwater from the Industrial Area Plume. Seep samples from a location immediately downgradient of this well also contained trace amounts of VOCs.

Walnut Creek Drainage Groundwater Contamination

Several wells in the area of the OU 6 trenches (IHSSs 166.1, 166.2 and 166.3) have detected low-level VOC and metal groundwater contamination. Neither the subsurface soil samples taken from the OU 6 trench area nor the wells within the nearby Present Landfill contain the same contaminants found in the OU 6 wells which are located outside of the Present Landfill slurry wall. However, wells upgradient of the Present Landfill and outside of the slurry wall exhibit similar contaminants and concentrations (see PU&D Yard plume above) (DOE 1996d and EG&G 1994).

There several theories for the occurrence of these low levels of VOCs and metals (DOE 1996d):

- The trenches (IHSSs 166.1 to 166.3) may be the source of contamination and the field investigation did not detect these sources,
- The Present Landfill is the source, and the southern intercept wall is inadequate,
- Wastes may have been emplaced beyond the southern slurry wall, or
- Contamination is from a source upgradient of the Present Landfill, potentially the PU&D yard.

VOC contaminated groundwater is found upgradient of the Present Landfill (average total VOC concentration of 71 ug/l), as well as south of the slurry wall (31 to 68 ug/l average total chlorinated hydrocarbons). In addition, well data indicates the south slurry wall is effective (EG&G 1994). Therefore, it is most likely that the contamination has migrated from a source upgradient of the Present Landfill.

4.3 CLEANUP ALTERNATIVES

The goal of this Groundwater Conceptual Plan is to manage and/or cleanup groundwater in order to be protective of surface water quality. The proposed cleanup of contaminated groundwater involves source removal or source containment, with treatment or management of the contaminated groundwater plumes, to achieve this goal. Conceptual remedies for each major contaminant plume were developed by assessing the available technologies, and proposing a cost-effective, readily available technology.

Both active and passive remedial actions were initially considered. Active treatment actions such as pump-and-treat methods are well-known and accepted, but typically have high operation and maintenance costs, can have a negative impact on wetlands, may consume groundwater, have limited application in clayey aquifers, and are relatively inefficient for DNAPL source removal. Passive treatment actions include passive collection of groundwater with *ex situ* or *in situ* treatment. These systems may have higher initial capital costs, but have lower operation and maintenance costs, low energy consumption, no water consumption, and reduced equipment requirements. Passive treatment will collect ~~DNAPL~~ contaminated groundwater, but also will not remove the source.

3574

The pump-and-treat methodology is commonly used and accepted. EPA has identified the pump-and-treat methodology as one of the most frequently used methods for groundwater remediation, but recognizes that pump-and-treat methods may require decades of potentially expensive operations to achieve cleanup levels (EPA 1992). A preliminary analysis was performed on the potential effectiveness of pump-and-treat methods at RFETS. The analysis concluded that pump-and-treat methods would not be an effective treatment for most contaminant plumes at RFETS, based on the following:

- Neither the UHSU nor the LHSU are capable of producing significant quantities of water, because both have a relatively large clay content.

- Aquifer tests conducted at RFETS show that, for the most part, aquifer yields are low, ranging from 0.000006 gpm to 12 gpm, with an average of 0.3 gpm (EG&G 1995b).

- Factors limiting water production within the UHSU include relatively thin saturated thicknesses and the presence of broad areas that become unsaturated during the fall and early winter (EG&G 1995b).

- Surficial deposits at RFETS have hydraulic conductivities in the 10^{-3} to 10^{-4} cm/sec range, whereas weathered and unweathered claystone bedrock have hydraulic conductivities in the 10^{-7} cm/sec range. The valley-fill alluvium is the most permeable unit, but no contaminant sources are known to be present in this unit.

- Due to the relatively low permeability of the geologic units at RFETS, cones of depression induced by groundwater removal would typically have very steep gradients, requiring a large number of closely spaced wells to effectively implement pump-and-treat remediation.

- Upgradient extraction of groundwater may adversely impact the present widespread distribution of seeps and springs (EG&G 1995b).

357

- Most of the contaminant plumes in RFETS groundwater have suspected DNAPL sources which ~~are difficult~~ are ineffective to remediate by using pump-and-treat or passive methods because: reword

  DNAPL being technically impract to remove

  OSWER directive

  - DNAPLs have low dissolution rates in water and are denser than water, and therefore tend to sink to the bottom of the unit;
  - The high clay content tends to adsorb DNAPLs, making these difficult or impossible to remove; and
  - Pump-and-treat remediation leaves residual DNAPLs, which will continue to act as a source, further releasing dissolved contaminants to the groundwater system.

It may be possible to implement pump-and-treat methods for groundwater near the East Trenches, where the No. 1 Sandstone is contaminated. However, a large number of closely-spaced wells would be required to effectively pump-and-treat groundwater due to the low conductivities and the resulting steep cones of depression. DNAPL contamination could easily remain after treatment. For these reasons, and the associated higher costs for this methodology, the pump-and-treat option was not considered as the proposed remediation treatment in this area.

When properly placed, a passive collection system near the distal ends of plumes will effectively capture the ~~DNAPL~~ dissolved-phase contaminated groundwater, but a contaminated plume would be left upgradient to naturally attenuate (DOE 1995h). The contaminants in the plume will degrade with time, and upgradient water will flush the source material toward the collection system.

All proposed actions discussed below were selected to be effective, inexpensive to install and operate, and require minimal plant infrastructure support. For these and the preceding reasons, passive treatment actions are the preferred proposed remediation.

Passive systems proposed for treatment of contaminant plumes in RFETS groundwater include:

- *In situ* passive collection and treatment system such as a funnel and gate, where contaminated groundwater is funneled into a reactive barrier by selective placement of relatively impermeable barriers. Treated water is released back into the groundwater

358

downgradient of the barrier. Such treatment systems have been used effectively at other sites.

- Collection of contaminated water from springs, seeps, and/or shallow drains, then pumping the collected water to an existing treatment facility (Building 891 Combined Water Treatment Facility), and discharging the treated water to the surface water system.

- Passive collection of contaminated water from springs, seeps, and/or shallow drains, then using gravity to feed the collected water through a nearby, *ex situ* treatment system, which uses granulated activated carbon, reactive iron, or other simple treatment options such as air strippers.

The passive treatments proposed in this plan could use any of these methods and are conceptual in nature. No engineering feasibility analyses were performed and the proposed remedial actions were not evaluated with regard to changing site conditions over time. Before implementation of any remedy, an evaluation will be done to determine the most appropriate, effective, implementable, and cost-effective remedy for each plume of contaminated groundwater. The result of these evaluations will be presented as part of ASAP, the 10 Year Plan, or in a planning or implementation document such as an Interim Measure/Interim Remedial Action (IM/IRA), along with the data used to make the decision. It is possible that, as a result of these evaluations, different remedial actions will be selected for the different contaminant plumes in RFETS groundwater.

Assumptions

The proposed conceptual remedial actions for treatment of contaminated groundwater were developed using the following assumptions.

- RFETS groundwater will not be used for domestic or other consumptive purposes, and there are no pathways for contaminated groundwater to directly impact human receptors.

- Groundwater will be managed or remediated to protect surface water and to minimize potential ecological impacts~~ due to entering the surface water system~~.

359

- Source removals or containment of subsurface soil sources will be designed to prevent further migration of groundwater containing contaminant concentrations greater than 100 x MCLs.

- Remediation and plume management will preserve wetlands where possible.

- Proposed actions will be implemented using cost-effective methodologies.

- Based on preliminary analysis, passive groundwater treatment or containment would appear to be the preferred remedial alternative for most contaminant plumes in RFETS groundwater.

- Performance monitoring will be conducted for all remediation systems to verify effectiveness.

- The remediation and management decisions described herein are based on the existing data set for contaminant plumes, as well as on known technologies that are believed to be applicable to treatment of RFETS groundwater.

- For this plan, the proposed actions are assumed to be passive treatment or containment devices. Passive treatment systems will be sited downgradient from the sources and coincident with the Tier I boundary within the plume, or where otherwise practicable and feasible. The actual remedial actions and location of these actions will be decided on a case-by-case basis and detailed in an IM/IRA or Proposed Action Memorandum (PAM) before implementation.

- An abbreviated alternatives analysis for any proposed action will be presented as part of ASAP or as an IM/IRA decision document.

- As per RFCA, contaminant plumes in RFETS groundwater which are stable and do not impact surface water above action levels will not require cleanup.

- All remedial actions will be consistent with the proposed end state of RFETS.

360

4.4 POTENTIAL CLEANUP ACTIONS

Using available information, the following potential actions were conceptually developed for each major VOC contaminant plume in groundwater. As contaminated seeps are the most distal ends of these contaminated groundwater plumes, these will be managed through cleanup of groundwater sources, natural attenuation, and/or interception at or upgradient of seep locations in accordance with the action level and Standards framework and the ER ranking. Further analysis of alternatives for feasibility, cost effectiveness, and suitability must be performed before initiating any action. Figure 4-1 shows the conceptual location of the groundwater actions.

4.4.1 Potential Action for the 881 Hillside Drum Storage Area Plume

The final remedy proposed for OU 1 is to excavate those soils containing VOC concentrations greater than the Tier I action levels. The volume of the source area requiring excavation is estimated at between 900 and 1,900 cubic yards of colluvium and weathered bedrock. Excavating the source will also remove much of the contaminated groundwater above Tier I action levels (Sampling and Analysis Report, 1996). After demonstrating that this proposed remedy has been effective, and that the source and much of the resulting contaminated groundwater have been removed, the French Drain and recovery well are expected to be removed from operation. fix the reference

This remedial action will be protective of surface water quality, and should reduce or eliminate any potential long-term stress to environmental receptors of contaminants that may reach Woman Creek.

4.4.2 Potential Action for the Mound Site Plume

X Cleanup of the Mound Site contaminated groundwater plume will consist of excavating the subsurface soil exceeding Tier I action levels for soil cleanup criteria for VOCs. Contaminated materials in Trench T-1 will also be removed using the same criteria. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches South Walnut Creek. Interception of the contaminant plume will be accomplished by making improvements to the existing seep collection system at SW059. The contaminated water is expected to be treated by a passive system installed along the south bank of South Walnut Creek.

Containment and treatment of the contaminant plume in Mound Site groundwater will result in a reduction of risk to the environment posed by uncontrolled releases of contaminated groundwater to surface water.

4.4.3 Potential Action for the 903 Pad and Ryan's Pit Plume

The proposed action is to remove contaminant sources exceeding the Tier I soil action levels for VOCs in soil from the 903 Pad area. Removal of the subsurface soils in the Ryan's Pit area has already been completed. The remedial action proposed for the groundwater with concentrations of VOCs in excess of Tier I action levels is to perform near-surface collection of the plume front before it reaches Woman Creek. The contaminated water is expected to be treated by a nearby passive system.

4.4.4 Potential Action for the Carbon Tetrachloride Spill Plume

There are three potential actions identified for this groundwater contaminant plume: (1) source removal by using shallow recovery wells to attempt to remove as much of the free-phase carbon tetrachloride as possible, (2) removal of the contaminated soils, adjacent tanks, and associated piping, and/or (3) *in situ* treatment such as steam stripping. At this time, the building infrastructure in the area is containing this plume. Monitoring must continue to ensure that contaminated groundwater does not impact surface water. After removal of the infrastructure, near surface capture of this plume may be required to minimize impacts to surface water. If required, the captured water will be treated at a nearby passive treatment plant. This area may be capped as part of the 10 Year Plan. The impact on groundwater must be determined to see if additional controls are necessary.

4.4.5 Potential Action for the East Trenches Plume

Source remediation for Trenches T-3 and T-4 was completed in 1996 to remove subsurface soils that exceed the applicable RFETS soil cleanup criteria for VOCs. This action removed the contaminant source of this contaminated groundwater plume. The remedial action proposed for the remaining contaminated groundwater plume is to install a near-surface plume capture system near the distal end of the plume, and to use passive technologies to treat the contaminated groundwater.

4.4.6 Potential Action for the IA Plume

This groundwater contaminant plume may not require action because source removal and D&D activities should remove contaminant sources, the source of water in the plume will be reduced over time as capping and/or regrading and revegetation reduces infiltration, and water loss from the RFETS utilities will be eliminated. Monitoring must continue to ensure that contaminated groundwater does not migrate, or create a threat to surface water. An upgradient groundwater barrier is not recommended as preliminary calculations indicate that only 15 percent of the present recharge (precipitation plus groundwater influx) to the IA could be diverted by an upgradient barrier, preventing approximately 4 gallons per minute of groundwater flux from entering the IA.

4.4.7 Potential Actions for Additional Plumes

Present Landfill Plume

An interim remedial action has been installed at this location to collect the contaminated groundwater and leachate flowing from the landfill for treatment. This gravity-driven system consists of cement vaults for collecting the contaminated water. Treatment includes a settling basin, bag filters to remove suspended solids, and granular activated carbon to remove organic chemical constituents. Contaminated water is treated to comply with established cleanup levels. This treatment should effectively mitigate the potential ecological risk from the contaminants of concern. The treatment system may change or be eliminated once the Present Landfill cap is installed, because groundwater migration may no longer be a concern.

Solar Ponds Nitrate Plume

Proposed remedial actions for the groundwater nitrate plume, if required, will be developed at a later date, based on final cleanup standards and site-specific hydrogeologic conditions. No source removal is planned for nitrate-containing media. However, a cap/cover is being considered, which would reduce the groundwater recharge and the flow through the nitrate-contaminated soils.

Recommendations from the Working Group, if approved by the Colorado Water Quality Control Commission (WQCC), will change the stream classification for nitrates from drinking water (10mg/l) to agricultural (100mg/l). There is some possibility that this surface water will be used for irrigation. Measures are being implemented which will restrict use of this water for domestic use. If the drinking water classification is lifted, then the nitrate concentrations seen in the surface water as a result of the nitrate plume are acceptable for all of the remaining uses, and could be of benefit for irrigation.

PU&D Yard Plume

A limited field investigation will be completed in 1997 to determine the impact to surface water. This may be followed by a source removal the same year. The limited field investigation will determine whether groundwater remedial action(s) are required to protect surface water.

Other 881 Hillside Groundwater Contamination

No action is required to mitigate this plume as it is not impacting, or expected to impact surface water. Any point sources around the building are expected to be dealt with during building demolition.

~~Old~~ Original Landfill Groundwater Contamination

The VOC contaminated groundwater associated with the ~~Old~~ Original Landfill is limited in extent, closely related to a small source area, and is not a threat to surface water quality. Therefore, this contaminated groundwater does not require any action.

Walnut Creek Drainage Groundwater Contamination

It is most likely that the contamination in this area has migrated from a source upgradient of the Present Landfill, potentially the PU&D Yard (see above). Contaminated groundwater in this area will be addressed as part of the remedy for the upgradient plume.

4.5 PLUME RANKING

Sources or contaminant plume above action levels that are determined to be candidates for remedial actions have been prioritized to determine the sequence in which remediation will occur. To accomplish this task, a methodology was developed by CDPHE, EPA, K-H, and RMRS staff to rank the known environmental risks at RFETS and is outlined in the "~~Environmental Restoration~~ (ER) Ranking" ~~(RMRS 1995)~~. (RFCA Att. __)

The ER ranking is currently being updated to incorporate the new action levels. Sites are ranked using the following criteria: 1) concentrations of contaminants present in soil, subsurface soil, and groundwater; 2) impact to surface water; and 3) the potential for further release which quantifies the possibility that source material will continue to release contaminants into the environment. The resulting prioritized list is used to determine the general order in which to implement remedial actions.

This methodology incorporates a very conservative approach. As a result, IHSSs, areas and groundwater plumes where formal risk assessments have determined that there is no unacceptable risk may rank higher than expected on the prioritized list.

The Working Group recommended that the groundwater plumes be prioritized separately from the contaminant sources to allow the groundwater actions to be initiated separately from the source removal actions. The methodology for ranking the groundwater plumes follows:

- **Action Level and Standards Framework Score**: Analytical data for VOCs in groundwater since 1990 were compared to the proposed Tier II action levels, and a ratio of the analytical result to Tier II action level value was calculated. The maximum ratio for each analyte within the contaminant plume was tabulated, and a total score for each groundwater plume was calculated by summing the maximum ratios. The resulting summed values were then converted to a Score Ratio using Table 4-1.

- **Impact to Surface Water**: A rating of 1 to 3 was assigned to each plume based on the evaluation of whether or not the groundwater contaminant plume was impacting surface water at Tier I action levels (a rating of 3), had the potential or was impacting surface water at Tier II levels (a rating of 2), or did not pose a threat to surface water at this time (a rating of 1).

- **Potential for Further Release**: A rating of 1 to 3 is assigned based on an evaluation of whether or not there is a potential for contaminants to continue to migrate into groundwater (i.e., is an uncontained source present?). If there is probably free product present, a rating of 3 is assigned, if high concentrations of contaminant are present in soil, a rating of 2 is assigned and if there is probably no uncontained source present, a rating of 1 is assigned. Because the groundwater plumes are ranked separately from the contaminant sources, and the contaminants are already in the groundwater, the potential for further release for all plumes is rated as a 1.

Table 4-1 Converstion Table for Scores

Summed Groundwater Ratios	*Score Ratio*
> 20,000	10
10,001 - 20,000	9
5,001 - 10,000	8
1,001 - 5,000	7
501 - 1,000	6
251 - 500	5
126 - 250	4
76 - 125	3
26 - 75	2
1 - 25	1

Framework

The ER Ranking was recalculated in September 1996 using the new action levels and standards, and including the groundwater contaminant plumes. Table 4-2 provides the rankings of the groundwater contaminant plumes above Tier I action levels as they appear within the overall ER Ranking.

366

Table 4-2 Ranking of the Groundwater Contaminant Plumes above Tier I Action Levels

Plume	*ER Ranking*	*Comments*
Mound Site	6	
903 Pad and Ryan's Pit	10	Ryan's Pit source removed
East Trenches	11	Trenches T-3 and T-4 sources removed
PU&D Yard	15	
881 Hillside Drum Storage Area	17	
Carbon Tetrachloride Spill	18	
IA	20	
Solar Ponds	22	Ranking due to nitrate concentrations
Present Landfill	26	Groundwater presently collected/treated

5.0 NEXT STEPS

What about modeling and test Pilot w/ Sandia money?

Additional data must be collected and/or analyzed before implementing actions. Not all groundwater contaminant plumes and sources are characterized sufficiently to implement an action, and appropriate methodologies for collection and treatment must be identified. The ecological impacts of groundwater collection and treatment must be determined, as collection of the distal plume boundaries may irreparably damage wetlands and seeps.

Before implementation of any remedy, a planning or implementation document such as an ~~Interim Measure/Interim Remedial Action~~ IM/IRA or PAM must be prepared, and an engineering design must be completed.

Based on the currently available information, following are the steps already completed towards groundwater remediation, and the proposed next steps. All of these activities have been proposed for funding within the next 5 years.

- Soils in OU 1 881 Hillside Drum Storage Area (IHSS 119.1) that contain contaminant concentrations above action levels may be excavated, removing material above the Tier I Action Level. Because the source of groundwater contamination would be removed, the use of the French Drain system and recovery well may no longer be necessary. After monitoring demonstrates the effectiveness of the remedy, these will be removed from service.

  The seep near Woman Creek will be evaluated to determine whether it is related to the 881 Hillside Drum Storage Area, and if there is an impact to surface water above action levels.

- The source of the Mound Site plume is anticipated to be remediated as an accelerated action. Pre-remedial investigations were completed in 1996 to delineate the extent of the contaminant source for this plume. Further pre-remedial investigations to determine the extent of the distal end of the groundwater contaminant plume, and effective, passive treatment methodologies are expected to continue in the near future. Gravity-flow passive treatment systems will be the preferred option.

368

investigations suggest that the contaminant source(s) may be located immediately east of the known PU&D yard boundary. Source removal is expected to follow in 1997 if a contaminant source can be defined.

- Soil vegetative caps, covers or regrading and revegatation may be used throughout RFETS where necessary to limit natural recharge caused by precipitation from leaching of contaminants in the unsaturated zone and into groundwater. This would aid in reducing the movement of groundwater through the IA, and thereby reduce the mobility of the contaminant plumes. Subsurface sources of groundwater contamination would be removed where practical. At the end of the D&D/remediation phase, the plant water supply and sanitary sewer will be shut off. This will eliminate a major source of groundwater recharge for the IA, and should greatly reduce the mobility contaminant of the IA and carbon tetrachloride spill plumes.

- A limited investigation is proposed for the Solar Ponds area to determine the extent of VOC contamination and whether there is a pathway to surface water. Carbon tetrachloride and trichloroethene are present at a well located near the western side of the SEPs. However, the extent of the contamination in the sandstone, and whether the sandstone subcrops in the North Walnut drainage are unknown.

Further analysis is required to determine optional intercept locations, actual treatment methodologies, and cost-effective project planning and scheduling.

The ER Ranking scheduled to be completed in 1996 incorp. in the IGD, and the proposed ranking of groundwater plumes presented in Section 4.5 provide the basis for establishing the priority and sequence of proposed cleanup actions. However, a schedule for implementing groundwater cleanup will be dependent on funding, data sufficiency, resource availability, and the integration with other cleanup and RFETS activities.

- The sources of the 903 Pad ~~and Ryan's Pit plume~~ are scheduled to be removed. The Ryan's Pit source has already been characterized and remediated. Pre-remedial investigations are proposed to determine the extent of the source. The distal ends of the groundwater contaminant plumes require better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred option.

- A pre-remedial investigation is proposed for the carbon tetrachloride spill plume (IHSS 118.1) to better define the source, and to evaluate remedial actions. After the source is better defined, source removal is recommended. A limited pump-and-treat system may be installed due to the large amount of free product present in a limited area. If required, after removal of the surrounding buildings and associated footing drain systems, a passive collection and treatment system may be installed to contain the dissolved phase of this plume. This system would be located along the post-building removal, downgradient flow path near the impacted drainage.

- The sources for the East Trenches plume have been removed. Accelerated actions were completed in 1996 to excavate Trenches T-3 and T-4, and materials above the Tier I action levels were removed. The distal end of this groundwater contaminant plume requires better definition in order to appropriately site collection and treatment systems. Gravity-flow passive treatment systems will be the preferred options.

- The IA plume will continue to be monitored to ensure that there is no increase in migration, and that there is no impact to surface water quality.

- Groundwater treatment systems need to be investigated to determine the optimum treatment methodology.

- The unknown extent of the chlorinated solvent plumes associated with the PU&D yard (IHSS 170, 174a, and 174b) is a data gap. Because the nature of the southern boundary of these plumes is undetermined, the potential impact to surface water cannot be evaluated. A limited characterization investigation is proposed for 1997 to determine the extent of the plume, and to determine the location, nature and size of the source material. Previous

370

6.0 REFERENCES

DOE, 1992a, *Final Groundwater Assessment Plan*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, February.

DOE, 1992b, *Final Historical Release Report for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, June.

DOE, 1993, *Final Groundwater Protection and Monitoring Program Plan for the Rocky Flats Plant*, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, October.

DOE, 1994a, *Final Phase III RFI/RI Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1*), June 1994.

DOE, 1994b, *RCRA Report*.

DOE, 1995a, *Accelerated Response Action Completion Report, Hot Spot Removal, RFETS, Operable Unit NO.1,* April 1995.

DOE, 1995b, *Final Phase II RFI/RI Report, 903 Pad, Mound, and East Trenches Area, Operable Unit No. 2,* October 1995.

DOE, 1995c, *Draft Data Summary 2, Operable Unit No. 9, Outside Tanks,* October 1995.

DOE, 1995d, *Draft Data Summary 2, Operable Unit No. 13, 100 Area,* June 1995.

DOE, 1995e, *Draft Data Summary 1, Operable Unit No. 14, Radioactive Sites,* June 1995.

DOE, 1995f, *OU 4 Solar Evaporation Ponds, Proposed Interim Measure/Interim Remedial Action, Environmental Assessment Decision Document,* February 1995

371

DOE 1995g, *Technical Memorandum 1, Operable Unit No. 10, Other Outside Closures,* January 1995.

DOE, 1995h, *Intrinsic Remediation Monitoring Task 1 Evaluation Report,* U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, March 1995.

DOE, 1996a, *Corrective and Remedial Action Proposed Plan, Rocky Flats Environmental Technology Site, Operable Unit 1 - 881 Hillside,* August 1996.

DOE, 1996b, *OU 4 Solar Evaporation Ponds Phase II Ground Water Investigation, Final Field Program Report,* February 1996.

DOE, 1996c, *Final Phase I RFI/RI Report Woman Creek Priority Drainage, Operable Unit 5,* April 1996.

DOE, 1996d, *Final Phase I RFI/RI Report Walnut Creek Priority Drainage, Operable Unit 6,* February 1996.

Driscoll, F. G., 1989, Groundwater and Wells, Third Printing, Johnson Division, St. Paul, Minnesota.

EG&G, 1992, *OU 2 Domestic Water Supply Simulations*, (Internal Report), EG&G Rocky Flats, Golden, Colorado, September, 9p.

EG&G, 1994, Technical Memorandum Final Work Plan OU 7, Volumes 1-4, RF/ER-94-00044, September.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

EG&G, 1995c, *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site*, Volume III of the Sitewide Geosciences Characterization Study, EG&G Rocky Flats, Golden, Colorado, January.

EG&G, 1995d, *1994 Well Evaluation Report for the Rocky Flats Environmental Technology Site (Final)*, EG&G Rocky Flats, Golden, Colorado, March.

EPA, 1992, *Chemical Enhancements to Pump-and-Treat Remediation*, U.S. Environmental Protection Agency EPA/540/S-92/001.

EPA, 1994, *Draft Soil Screening Guidance*, U.S. Environmental Protection Agency, EPA/540/R-94/101.

RMRS, 1995, *Environmental Restoration Ranking*, RMRS Rocky Flats, Golden, Colorado, September 27.

RMRS, 1996a, *White Paper - Analysis of Vertical Contaminant Migration Potential - Final Report, RF/ER-96-0040.UN*, report prepared for Kaiser-Hill Company, August 16, 1996.

RMRS, 1996b, *Sampling and Analysis Report, Identification and Delineation of Contaminant Source Areas for Excavation Design Purposes, IHSS 119.1, OU 1*, April 1996

RMRS, 1996c, *Trenches and Mound Site Characterization Report, RF/ER-96-00044.UN*, September 1996.

RMRS, 1996d, *Management Plan for the Interceptor Trench System Water, RF/ER-96-0031.UN*, July 1996.

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BTEX

ASAP	Accelerated Site Action Plan
CDPHE	Colorado Department of Public Health and Environment
D&D	Decontamination and Decommissioning
DNAPL	Dense Nonaqueous Phase Liquid
DOE/RFFO	Department of Energy/Rocky Flats Field Office
EPA	Environmental Protection Agency
GMAP	Groundwater Monitoring and Assessment Plan
GPMPP	Groundwater Protection and Monitoring Program Plan
GWAP	Groundwater Assessment Plan
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
K-H	Kaiser-Hill
LHSU	Lower Hydrostratigraphic Unit
MCL	Federal Drinking Water Maximum Contaminant Level
OU	Operable Unit
PA	Protected Area
PAM	Proposed Action Memorandum
PPRG	Programmatic Risk-Based Preliminary Remediation Goal
PU&D	Property Utilization and Disposal
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services, L.L.C.
SNM	Special Nuclear Material
TRU	transuranic
UHSU	Upper Hydrostratigraphic Unit
VOC	Volatile Organic Compound
WQCC	Colorado Water Quality Control Commission

379

Appendix B

Executive Summary of the White Paper

Analysis of Vertical Contaminant Migration Potential - Final Report,

RF/ER-96-0040.UN, report prepared for Kaiser-Hill Company,

August 16, 1996.

376

EXECUTIVE SUMMARY

This white paper was prepared as part of a comprehensive environmental initiative, known as the Accelerated Site Action Project, that seeks to establish long-term goals and approaches for the remediation of the Rocky Flats Environmental Technology Site. The purpose of this white paper is to describe and analyze the potential for shallow groundwater contaminants, particularly volatile organic compounds, to migrate vertically downward through a thick, laterally extensive confining layer and enter a deep regional artesian aquifer system known as the Laramie-Fox Hills Sandstone aquifer. The Laramie-Fox Hills Sandstone aquifer provides an important source of water for local and regional use and is the sole water supply for some residents in the Rocky Flats area.

Concerns related to contaminant migration and the long-term hydrologic integrity of this confining layer have recently been raised regarding the presence of dense non-aqueous phase liquids (DNAPLs) in the groundwater at some waste disposal sites and the occurrence of secondary permeability (i.e., fractures and faults) in bedrock materials. The combination of these factors at other hazardous waste sites have led to persistent groundwater contamination problems that have proven to be difficult to remediate and, thus, represent a long-term contaminant migration threat. In order to evaluate the potential significance of vertical groundwater contaminant transport at Rocky Flats Environmental Technology Site, two individual hazardous substance sites (IHSSs 110 and 118.1) with evidence of chlorinated solvent releases were selected for analysis and discussion. The primary DNAPL and dissolved contaminants-of-concern identified at these sites are trichloroethene, tetrachloroethene, and carbon tetrachloride. Information from numerous site reports, unpublished site data, and recently published articles provide the basis for the analyses presented in this white paper.

The Rocky Flats Environmental Technology Site is underlain by a mantle of permeable Quaternary surficial geologic deposits deposited on a 600+ foot thick sequence of low permeability Cretaceous claystone and siltstone bedrock known as the upper Laramie Formation. The upper Laramie Formation functions as a confining layer for the underlying Laramie-Fox

Hills Sandstone aquifer which subcrops west of the Industrial Area and plunges eastward beneath the plant. Vertical hydraulic conductivities for the confining layer materials are estimated to range from about 2.8×10^{-10} to 2.5×10^{-7} centimeters/second, or roughly three to seven orders of magnitude lower than for the overlying surficial deposits. Due to this contrast in hydraulic conductivity, groundwater is expected to move predominently laterally in the surficial deposits and vertically in the confining layer. Downward vertical hydraulic gradients observed in the confining layer indicate that shallow groundwater has the potential to recharge the Laramie-Fox Hills aquifer.

Faulting in the upper Laramie Formation has been documented regionally and recently has been documented at the Industrial Area. The influence of these fault zones on vertical groundwater flow is unknown; however, an observed trend of decreasing claystone permeabilities with depth is expected to result in a restrictive, rather than an enhanced, vertical groundwater flow regime. Fractures observed in bedrock core samples tend to be discontinuous, sub-horizontal to sub-vertical, and closed with depth. Trace concentrations of trichloroethene, tetrachloroethene, carbon tetrachloride, and chloroform found in some unweathered bedrock wells indicate that limited contaminant migration has occurred in the shallowest part of the confining layer beneath shallow groundwater plumes with high concentrations, although most detections are apparently related to laboratory or well cross contamination. Plutonium-239/240 was detected above background in three unweathered bedrock wells, but the available evidence indicates that these occurrences are attributable to cross contamination probably as a result of drilling through radionuclide contaminated soils.

Estimates of the vertical groundwater flow velocity through the confining layer indicate that groundwater movement is expected to be very slow. The calculated range of groundwater velocities, based on a potential range of vertical hydraulic conductivities, is 0.00054 to 0.468 feet/year, which translates to travel times to the Laramie-Fox Hills aquifer of 1,300 to 1.1 million years. Consideration of the hydrologic setting and declining hydraulic conductivity trend with depth suggests that the actual groundwater flow velocity will be near the low end of the range.

378

Analysis of the behavior of dense nonaqueous phase liquids indicates that a potential exists for entry of DNAPL into fractured bedrock. However, the threat of DNAPL migration to the Laramie-Fox Hills aquifer is rapidly mitigated by diffusive disappearance of DNAPL from fractures into the claystone matrix, which has a large contaminant mass storage capacity. Dissolved and sorbed volatile organic contaminants derived from DNAPLs therefore represent the principal concern for vertical contaminant migration to the deep aquifer.

Organic contaminants are expected to move much slower than the groundwater flow velocity in the confining layer due to the effects of sorption by high organic carbon and clay contents, dispersion and molecular diffusion, and possibly *in situ* abiotic transformation reactions. The most rapidly transported contaminant, trichloroethene, is predicted to travel for 17,000 to 15 million years before reaching the Laramie-Fox Hills aquifer, with the most likely case being on the order of a hundred thousand years or more. Assuming that natural contaminant degradation is a viable process, some contaminants with short environmental half lives, such as carbon tetrachloride, may fully degrade before reaching the aquifer. The results of simple one- and two-dimensional analytical modeling of contaminant transport indicate that dispersion will reduce contaminant concentrations at the confining layer/aquifer interface by 6 to 99 percent, depending on magnitude of the vertical flux. Under worst case conditions, the resulting contaminant concentrations derived from mass flux calculations in the Laramie-Fox Hills aquifer exceed regulatory limits; however, these calculations are exceedingly conservative and ignore some important basic factors. Using a more realistic set of assumptions, it is expected that, if contaminants should ever reach the aquifer, the concentrations will be below regulatory limits.

It is concluded from this review and analysis that the upper Laramie Formation confining beds have a sufficient amount of hydrologic and geochemical integrity to provide long-term protection of the Laramie-Fox Hills aquifer. Monitoring of vertical contaminant migration at potential bedrock source areas, rather than remediation, appears to be the most prudent and cost effective option for protection of the Laramie-Fox Hills aquifer given the apparent robust geochemical nature of unweathered bedrock materials underlying the site.

Draft Groundwater Strategy Contaminated Areas above PPRG

1.0 881 Hillside IHSS

Groundwater Sources

In the immediate vicinity of the 881 Hillside, two areas of elevated VOA concentrations relative to the PPRGs were found in groundwater. The contaminants were found in alluvial wells and shallow bedrock wells in the first area which lies immediately south of IHSS 119.1. The 881 Hillside Collection Well CW001 near well 4387, is currently extracting groundwater from this area and conveying it to Building 891 for treatment. Contaminants of Concern (COC) in this plume include carbon tetrachloride (CCl_4), trichloroethene (TCE), 1,1 dichloroethene, 1,2 dichloroethane, and tetrachloroethene (PCE). A smaller plume near well 0187, contains 1,1 DCE at 1.4 times the PPRG. A single capture well is proposed for this plume with a 204 foot interceptor trench as an alternative.

2.0 903 Pad, East Trenches, Mound and Associated IHSS

Groundwater Source

A large plume (approx. 70 acres) and four small plumes (approx. 0.5 acres each) occur in this area. Contamination occurs in the Rocky Flats Alluvium and shallow bedrock. Contaminants include Carbon tetrachloride, Trichloroethene, tetrachloroethene, chloroform, methylene chloride, 1,1 dichloroethene, and vinyl chloride. Concentrations range from generally 1.5 to several times the PPRG. Approximately 50 wells including five bedrock wells would be required to contain and treat these plumes. An aggregate maximum well production rate of 37.5 gpm could be expected in the wet season. Alternatively, 4012 feet of interceptor trench could be constructed, or a combination of wells and trenches.

3.0 Industrial Area IHSS

Groundwater Source

Six chlorinated solvent plumes occur in the Rocky Flats Alluvium within the Industrial Area. Contaminants include carbon tetrachloride, tetrachloroethene, vinyl chloride, and 1,1 dichloroethene. Concentrations range from 1.1 to nearly 30 times the PPRG. Fifteen wells or 1593 feet of interceptor trenches would be required for containment.

4.0 Solar Ponds Interceptor Trench

Groundwater Source

A groundwater plume containing nitrate at approximately 1.4 times the PPRG exists about the well P208989. The contamination is primarily contained in groundwater within the Rocky Flats Alluvium, weathered bedrock, and the Number 1 Sand. Presently, this plume is partially captured by the Interceptor Trench System. The ITS is not fully effective, but the area above PPRG has yet to extend downgradient beyond the ITS. Two collection wells or a new 565 foot interceptor trench could provide effective capture of this source. The combined production rate from the wells would be on the order of 1.5 gpm. Based on modeling results, the capture radius of the wells would be approximately 75 to 100 feet.

382

Draft Groundwater Strategy Contaminated Areas above PPRG

5.0 Old Landfill and Associated IHSS

Groundwater Source

Two monitoring wells south of the old landfill show elevated beryllium concentrations relative to PPRG. Well 59593 is located on the southern edge of IHSS 115 and well 58793 is located on the southeast corner of IHSS 133.3. These areas are located within the outcrop area of the Rocky Flats Alluvium. The data from wells 59593 and 58793 show unfiltered total Be values of 20.30 and 29.40 UG/L in June 1993 samples. These values exceed PPRG by ratios of approximately 1.1 and 1.6. No VOC, water quality, or Rad exceedences of PPRG have occurred in groundwater samples obtained from these wells.

6.0 A and B Series Ponds and Associated IHSS

Groundwater Source

No groundwater sources above the PPRG have been identified for this area.

7.0 Present Landfill and Associated IHSS

Groundwater Source

An area surrounding wells 72393 and 72093 located near the center of the present landfill shows PCB (Arochlor) contamination at a level of 1.07 times the PPRG. An approved Proposed Action Memorandum has designated the construction of a passive collection and treatment system as the preferred remedy for the initial treatment of landfill leachate. A single extraction well could be placed near well 72393 if further action is warranted. Production rates from such a well could be up to several gallons per minute.

383

RFETS SITEWIDE PUMP AND TREAT VOLUME ESTIMATES

Assumptions:

1. Capture radius for containment wells assumed to be 75 feet based on the range of values from simulation results presented in OU-2 CM/FS Report..

2. Assumed pumping rate of 0.75 gpm is based estimates given in OU-2 CM/FS Report. This rate is for wet season conditions and may not be sustainable throughout the year. This rate was assumed for all wells.

3. The well placement for the main OU-2 contaminant area was designed primiarly for containment and capture of the contaminanted groundwater using wells along the preimeter of the contaminated area. The number of wells for other contaminated regions was based on caputre of the groundwater with wells within the contaminated area.

REGION	SURFICIAL MATERIAL WELLS	BEDROCK WELLS	TOTAL
OU-2 (main)	40	5	45
OU-2 (secondary)	5		5
OU-1	2		2
Industrial Area	15		15
Present Landfill	1		1
TOTAL	63	5	68

68 wells @ 0.75 gpm yields 51 gpm (3,060 gph, 73,440 gpd)

384

REVIEW COMMENT SHEET

Please review the attached procedure: RF/ER-95-0121.UN (Number) 3 (Rev.) Final (Draft) Groundwater Conceptual Plan for the RFETS, Sept. 1996 (Title)

Comment Due Date: 09/19/96

☐ Internal Review ☐ Parallel Review ☐ Verification ☐ Validation ☐ Revalidation

QA X Peer ____

General (G) comments require resolution but do not require resolution acceptance. Mandatory (M) comments require resolution and resolution acceptance. 1-88000-PP-004 provides complete definitions of General and Mandatory comments.

ITEM G or M	PAGE	SECTION OR STEP	COMMENT	RESOLUTION	Resolution accepted INIT/DATE
G	ES-1	ES	Change 3rd sentence to read "contamination" or "contaminated groundwater".	Sentence deleted	[initials] 9-23-96
G	1-1,1-2	1.1	The last sentence needs to be clarified - include "and" as well as "proposed appropriate industrial or open space uses". I don't believe anything has been confirmed for the use of the RFETS at this time.	done	[initials] 9-23-96
G	1-2	1.1	1st para. 2nd sentence - include "to implement...".	done	[initials] 9-23-96
G	3-2	3.2.1	Delete 2nd and last sentence of the para. since these values have been approved by the regulators as well as the stakeholders.	revised	[initials] 9-23-96
M	3-2	3.2.1	2nd para., 2nd sentence needs to be clarified. Do Tier I wells with contaminants exceeding MCLs be mitigated through accelerated actions?	revised	[initials] 9-23-96
M	4-14	4.2.1	Include title of map.	~~done~~ modified text	[initials] 9-23-96

POC/Reviewer: (Comments not signed by Reviewer/POC will be considered unofficial and not subject to resolution)

☐ No Comments

☐ This procedure revision has no impact or relevance to our discipline or organization and we waive need to concur. We acknowledge this concurrence waiver does not affect our responsibility to implement the requirements of this procedure when needed.

Greg DiGregorio (Name) Greg D DiGregorio (Signature)

5688/1732 (Ext./Pager/Fax) T893B/ER QA (Bldg./Dept.) 09/19/96 (Date)

Return to:

FAX ____ Name ____ Ext. ____ Location ____

If questions on content, please call the SME:

Name ____ Ext. ____

388

erqa/grndwtr/gwcncpl3.wpd

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for development of the action levels and standards framework for surface water, ground water, and soils. Protection of surface water quality is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and all three media were considered in developing a sitewide strategy for RFETS.

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (Attachment 5 of RFCA, July 19, 1996) was recently modified to incorporate the clarifications and resolutions of issues that were reached after RFCA was signed. The proposed changes are expected to be completed by October 18, 1996. Appendix B contains these proposed action levels and standards. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water quality and ecological resources.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water quality. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gauging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources.

This framework for groundwater action levels is based on the assumption that contaminated groundwater emerges as surface water before leaving RFETS.

3.2.1 Action Levels

The Working Group has defined the action level for groundwater Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated cleanups, and Tier II action levels are protective of surface water quality. This approach is described below.

Tier I

Groundwater Tier I action levels are based on 100 times the MCL (100 x MCL) and were developed to identify potential cleanup targets. Contaminant concentrations in groundwater above the Tier I action levels indicate the presence of groundwater contaminant sources which may pose a risk to surface water quality. If Tier I action levels are exceeded, an evaluation is required to determine if source removal, or other cleanup or management action is necessary to prevent highly contaminated groundwater (i.e., contaminant concentrations exceeding 100 x MCLs) from reaching surface water. (The evaluation process is described in Section 4.1). This report represents the first phase of this evaluation.

Where action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional contaminated groundwater that does not exceed the Tier I action levels may also need to be remediated or managed to protect surface water quality or ecological

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination. Reference needed

resources. The plume areas to be remediated and the cleanup levels or management methods used, will be determined on a case-by-case basis.

Tier II

The Tier II VOC action levels for surface water quality protection were developed to prevent contaminated groundwater from reaching surface water. When Tier II action levels are exceeded at the designated Tier II wells, groundwater management actions are triggered. Tier II wells are located downgradient of existing plumes to detect the possible spread of the contaminant plumes. If concentrations in a Tier II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than Tier II action levels will trigger a groundwater action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

The Tier II action levels will be applied only at certain wells as described in Section 3.2 of Appendix B. Table 3-1 presents the list of groundwater monitoring wells designated as Tier II monitoring locations. These wells are located at or near the boundaries of the composite VOC plumes shown in Figure 3-1, as described in Section 4.2. Additional Tier II monitoring wells may be installed, if necessary. The results of groundwater sampling and analysis at these wells will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

Table 3-1 Tier II Groundwater Monitoring Wells

Well Number	*Well Number*
6586	P314289
23196	P313589
23296	7086
75992	10992
06091	1786
23096	10692
10194	4087
1986	B206989
1386	

Insert Figure 3-1

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier II wells identified in this Report, will soon be incorporated into an Integrated Monitoring Plan (IMP). The document will incorporate two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). The document also will describe recent changes to the groundwater monitoring network.

The IMP will list the wells with their appropriate data quality objectives, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The IMP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. The present groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, until changes proposed in the IMP are agreed to by all parties. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water quality through groundwater transport of leached contaminants. As there are too many variables to accurately model transport of inorganics (e.g., metals and radionuclides) in subsurface soils at RFETS, the Tier I action levels are the same as Tier I action levels for the corresponding contaminants in surface soil. These action levels are human-health risk-based for the appropriate receptor (office work or open-space recreational user), and are conservative since future land use scenarios do not include contact with subsurface soil.

Action levels for VOCs in subsurface soils were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to determine the equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Subsurface soil contaminant levels that would be protective of groundwater to Tier I action levels of 100 x MCLs were then calculated. These action levels for subsurface soils and are provided in Table 4 of Appendix B.

Tier I action levels for radionuclides in subsurface soils are the same as applied as Tier I action levels for radionuclides in surface soils. with the total dose from multiple radionuclides calculated by the sum-of-ratios method. These action levels are the more conservative of:

- An annual radiation dose limit of 15 mrem for the appropriate land use receptor, or
- An annual radiation dose limit of 85 mrem for a hypothetical future resident assuming failure of passive control measures.

Additional subsurface soil may need to be remediated or managed to protect surface water quality or ecological resources. These additional sites will be determined on a case-by-case basis.

3914

4.2.1 881 Hillside Drum Storage Area Plume

The 881 Hillside Drum Storage Area (IHSS 119.1) was in use from 1968 to December 1971. Primarily empty drums and scrap metal were stored at this location. Some of the drums had previously contained solvents and other organic chemicals. Other drums may have contained solvents or other organic chemicals contaminated with plutonium as the hotspots removed in 1994 from this location had elevated plutonium levels.

The OU 1 881 Hillside is located on a south facing hillside that slopes downward from Building 881 to Woman Creek (Figure 4.2.1-1). The 881 Hillside is crossed by the South Interceptor Ditch (SID) which was designed to intercept surface water flow from the plant. In 1992, a French Drain was installed across the 881 Hillside to intercept contaminated UHSU groundwater suspected to be flowing down the 881 Hillside. A 3-ft-diameter recovery well was installed in an area of known contaminated groundwater to recover water containing high levels of dissolved VOCs.

Here, groundwater occurs in the unconsolidated surficial materials. The surficial materials and underlying 5 to 25 feet of weathered claystone are 100 to 10,000 times more permeable than the underlying unweathered claystone. This significantly limits the flux of groundwater into and through the unweathered claystone (DOE 1994a, DOE 1995a).

Groundwater at the 881 Hillside does not exist within a continuous, homogenous, shallow aquifer system. The UHSU has a highly variable lithology and is not uniformly saturated across the Hillside. Large areas are dry, or contain water only in the Spring when water table elevations are typically the highest. Groundwater is typically found in disconnected northwest-southeast trending paleochannels cut into the bedrock surface where there is a thicker section of colluvium and/or alluvium. Dry areas appear to be coincident with bedrock highs and other areas with thinner sections of colluvium and/or

INSERT FIGURE 4-2.1-1

alluvium. The bedrock topography and surficial deposit thickness can be used to extrapolate where groundwater flow may occur (DOE 1994a).

Recharge to the UHSU is primarily through precipitation, with minor seepage from the Rocky Flats Alluvium. Discharge is primarily from evapotranspiration due to the dry climate and slow percolation rates, and is enhanced by the south facing slope of the Hillside. Discharge also occurs to the French Drain, the recovery well, and to surface water. Several small seeps are found along Woman Creek and along slump boundaries where UHSU groundwater intersects the surface.

Aquifer tests estimate the average flow velocity at 70 feet per year near the 881 Hillside Drum Storage Area. Hydraulic conductivities of the surficial materials range from 3×10^{-3} to 2×10^{-6} cm/sec. The transmissivity of the UHSU was calculated as 1.2×10^{-6} m^2/sec, approximately 100 times less than what Driscoll (1989) considered sufficient to supply water for domestic or other low yield purposes. The volume of UHSU groundwater within the entire OU 1 881 Hillside Area was estimated at 5 acre-feet in April 1992.

Groundwater data collected since the installation of the French Drain suggests that it is successful in collecting much of the UHSU groundwater. For example, the UHSU monitoring wells downgradient of the French Drain are generally dry, suggesting that the area has been dewatered (DOE 1994a).

The 881 Hillside drum storage area (IHSS 119.1) is the site of historic releases of chlorinated VOCs to the environment from drums stored at this location (Figure 4.2.1-1). These releases have resulted in the contamination of shallow alluvial groundwater which has formed a small contaminant plume extending about 300 feet to the south-southeast down the 881 Hillside along a paleochannel incised into the underlying weathered claystone. Unconsolidated sediments on both sides of this plume are unsaturated.

The source of the groundwater contamination was further characterized during the 1996 field program to obtain sufficient data to plan a source removal. The field investigation identified two potential source areas: one immediately east of the collection well and one 50 feet northwest of the collection well (Figure 4.2.1-1). The eastern source area underlies one of the radiological hot spots removed in 1994. Both source areas could have been caused by leakage from individual drums (RMRS 1996b).

The contaminants in the plume which exceed Tier I concentrations are primarily carbon tetrachloride, 1,1 dichloroethene, tetrachloroethene, 1,1,1-trichloroethane and trichloroethene. Figure 4.2.1-1 provides the distribution of contaminant concentrations in groundwater at this location. A small seep located south of IHSS 119.1 and downgradient of the French Drain along Woman Creek was sampled once and this sample contained a trace amount of VOCs. It is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

The contaminated groundwater plume is upgradient of the French Drain and does not appear to be increasing in size. The recovery well is located within this plume and collects approximately 100 to 150 gallons per day. This well appears to collect most of the contaminated groundwater originating from the contaminated groundwater plume. The French Drain remains in operation and continues to collect relatively uncontaminated groundwater which is treated at the Building 891 Consolidated Water Treatment Facility. The area immediately downgradient of the French Drain is unsaturated, indicating that the French Drain has dewatered much of the area.

The preferred remedy for this plume is source removal which was mandated by the 1995 dispute resolution committee composed of DOE RFFO, EPA and CDPHE. A Record of Decision (ROD) is currently in progress which will establish a remedial action based on the Public Comments to the recommended alternative of source excavation presented in the Proposed Plan (DOE 1996a).

FACSIMILE COVER SHEET

Date: 9/19/96 **No. of Pages (including cover):** 9

To: Annette Primrose	**From:** CM Brooks
Company:	**Company:** Kaiser-Hill
Phone No.: 4385	**Phone No.:**
Fax No.: ~~4844~~ 2623	**Fax No.:**

Comments:

Annette - Hi! Overall looks good. I had a few suggestions - the main one is to correct Section 3.3 Subsurface soils to correctly reflect approach taken for action levels for organics.

I'm faxing the proposed lang/approach. We hope to have this finalized by 10/18/96.

399

radiation dose are near their respective Tier I action levels.

Section 5 of the ALF commits to forming a working group to investigate the applicability of using a dose basis rather than a risk basis for calculating action levels for radionuclides in surface soils. This working group determined that dose-based values are more appropriate and should be used. A document entitled Action Levels for Radionuclides for the Rocky Flats Cleanup Agreement presents these proposed action levels for radionuclides as well as justification for their derivation. This document also contains proposed modifications to Table 5 and Sections 4 and 5 of the ALF.

~~Tier I action levels for organic compounds in subsurface soils have been calculated based on each compound's ability to leach to groundwater. Those calculated values are in Table 4.~~ Since the subsurface soils at RFETS are highly heterogeneous and because of other variables, it is not currently possible to accurately model transport of inorganics in subsurface soils. Therefore, ~~it is proposed that the~~ action levels for inorganic contaminants (e.g., metals and radionuclides) in subsurface soil be the same as action levels for the corresponding contaminants in surface soil. These action levels are, therefore, human-health risk-based for the appropriate land-use receptor (office worker or open-space recreational user). This application of surface soil action levels as subsurface soil action levels is conservative since the controlled future land use scenarios for RFETS do not include contact with subsurface soil.

The following language is proposed to replace the referenced sections of the ALF. Bolded words are proposed additions; struck-out words are proposed deletions.

4.0 SUBSURFACE SOILS

4.2 Action Levels
[as is]

A. Tier I

1. All subsurface soils capable of leaching ~~contaminants~~ **organic compounds** to ground water at concentrations greater than or equal to 100 x MCLs. Where an MCL for a particular contaminant is lacking, the residential ground water ingestion-based PPRG value will apply. Contaminant-specific Tier I action levels for ~~volatile~~ organics ~~contaminants~~ have been determined using a soil/water partitioning equation and a dilution factor from EPA's Draft Soil Screening Guidance (1994). These derived values and ~~the~~ parameters used to derive them......the derived values may need to be recalculated.

2. **Tier I action levels for inorganic contaminants in subsurface soil are the same as Tier I actions levels for the corresponding contaminants in surface soil. These action levels are, therefore, human-health risk-based for the appropriate land-use receptor (office worker or**

400

3.0 ACTION LEVELS AND STANDARDS

The RFCA Preamble was used as the basis for the development of the Action Levels and Standards Framework for Surface Water, Ground Water, and Soils ~~action levels and standards developed by the Working Group~~. Protection of surface water is the primary basis for the cleanup and/or management of contaminated subsurface soil and groundwater at RFETS. Surface water, groundwater, and soil cleanup are interrelated, and ~~the Working Group considered~~ all three media were considered in developing a sitewide strategy for RFETS.

((reference to RFCA p. [illegible]-57))

The *Action Levels and Standards Framework for Surface Water, Ground Water, and Soils* (July 19, 1996) is attached as Appendix B. The following sections summarize the approaches delineated in this document for monitoring and remediating surface water, groundwater, and subsurface soils for the purpose of protecting surface water.

3.1 SURFACE WATER

Groundwater will be managed to protect surface water. During active remediation, surface water quality standards and surface water management activities will be different than those applied after remediation. The water quality standards will apply at points-of-compliance located at the outfalls of the terminal ponds and at the Site boundary. These values will also be used as action levels upstream from the terminal ponds at existing gaging stations. When cleanup activities are complete, on-site surface water will meet surface water quality standards.

3.2 GROUNDWATER

As stated in the RFCA Preamble, domestic use of groundwater at RFETS will be prevented through institutional controls. Because no other human exposure to groundwater is foreseen, groundwater action levels are not based on human consumption or direct contact. Instead, action levels for groundwater have been selected to be protective of surface water quality and ecological resources. This framework for groundwater action levels is based on the ~~conclusion~~ assumption that contaminated groundwater emerges as surface water before leaving RFETS.

3.2.1 Action Levels

Post-it® Fax Note 7671	Date	# of pages ▶ 7
To Laura Brooks	From A.L. Primrose	
Co./Dept.	Co.	
Phone # 6130	Phone # 4385	
Fax # 64016	Fax #	

Please Review

401

for groundwater

The Working Group has defined the action levels for Volatile Organic Compounds (VOCs) only, based on Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (see Appendix B). MCLs are well-established and accepted values that have been used to guide cleanup at other contaminated sites. Where an MCL for a particular VOC contaminant is lacking, the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG)* value will apply. A two-tiered action level approach to groundwater cleanup and monitoring was developed to protect surface water and identify areas of groundwater contamination potentially requiring cleanup. Tier I action levels consist of near-source action levels for accelerated clean-ups, and Tier II are action levels protective of surface water. This approach is presented in the following paragraphs.

Tier-I

Action levels were developed to identify potential cleanup targets in areas where VOC contamination of groundwater exceeds 100 times the MCL (100 x MCL). These action levels identify groundwater contaminant sources that present a higher potential risk to surface water and that should potentially be addressed through an accelerated action. If Tier-I action levels are exceeded, an evaluation is required to determine if remedial or management action is necessary to prevent the highly contaminated (i.e., contaminant concentrations exceeding 100 x MCLs) groundwater from reaching surface water (the evaluation process is described in Section 4.1). If action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. Additional groundwater that does not exceed the Tier-I action levels may also need to be remediated or managed to protect surface water quality or ecological resources. The plume areas to be remediated and the cleanup levels or management techniques used, will be determined on a case-by-case basis. Wells that yield groundwater that is contaminated with VOC concentrations exceeding 100 x MCLs are considered Tier-I wells.

Tier-II

* PPRGs were developed and approved by DOE, EPA, CDPHE, and EG&G to establish sitewide cleanup targets for environmental contamination. incl. ref date

402

The VOC action levels for surface water protection were developed to prevent contaminated groundwater from reaching surface water, by triggering groundwater management actions when necessary. Tier-II wells are located downgradient of existing plumes, in order to detect the possible spread of the contaminant plumes. If concentrations in a Tier-II well exceed MCLs during a regular sampling event, monthly sampling of that well will be required. Three consecutive monthly samples showing contaminant concentrations greater than groundwater action levels will require a groundwater remedial action. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. Such actions will be incorporated into the Environmental Restoration Ranking and will be given weight according to measured or modeled impacts to surface water.

A detailed discussion of where Tier-II action levels will be measured is found in Section 3.2 of Appendix B. Table 3-1 presents a list of three new wells and a subset of existing groundwater monitoring wells that are designated as Tier-II monitoring locations. Figure 3-1 shows the location of Tier-II monitoring wells relative to the composite VOC plumes as described in Section 4.2. Additional Tier-II monitoring wells may be installed, if necessary.

The existing Tier-II wells are currently in the groundwater monitoring network. The new Tier II monitoring wells will be added to the groundwater monitoring network upon completion of well installation and development activities. The results of groundwater sampling and analysis will be integrated with concurrent surface water data for the purpose of evaluating potential impacts to surface water.

403

Table 3-1 Tier-II Groundwater Monitoring Wells for VOCs

Location Code	Comments
6586	
New Well	Upstream of 6586
New Well	Between B-2 and B-3
75992	
06091	
New Well	Near C-1 (Downgradient of Ryan's Pit)
10194	
1986	
10994	
P314289	
P313589	
7086	
10992	
1786	
1386	
10692	
4087	
B206989	

Groundwater Monitoring

All long-term monitoring requirements for RFETS, along with the Tier-II wells identified in this Groundwater Conceptual Plan, will soon be incorporated into a Groundwater Monitoring and Assessment Plan (GMAP). This document will incorporate two pre-existing plans: (1) the Groundwater Protection and Monitoring Program Plan (GPMPP) (DOE 1993); and (2) the Groundwater Assessment Plan (GWAP) (DOE 1992a). This document will also describe recent changes to the groundwater monitoring network.

404

Insert Figure 3-1

405

The GMAP will list the wells with their appropriate regulatory driver, the sampling frequency, and analyte suite, as well as describe data evaluation and reporting methodologies. The GMAP will also reference other implementation plans and decision documents from which the requirements are derived, and will be updated regularly as programmatic changes occur.

The groundwater monitoring network will continue to operate as recently modified by the Groundwater Monitoring Working Group, unless subsequent changes are agreed to by all parties.
Has this WG been defined elsewhere (who, purpose, etc.)

Analyte suites, sampling frequency, and specific monitoring locations will be evaluated annually to adjust to changing conditions such as plume migration and increased understanding of contaminant distributions. All groundwater monitoring data, as well as changes in hydrogeologic conditions and any exceedance of groundwater action levels, will be reported quarterly and summarized annually.

All groundwater remedies, as well as some soil remedies, will require groundwater performance monitoring. The amount, frequency, and location of any performance monitoring will be based on the type of remedy implemented and will be determined on a case-by-case basis within the specific decision documents.

3.3 SUBSURFACE SOILS

Action levels for VOCs in subsurface soils were developed to be protective of surface water through groundwater transport. The VOC contaminant plumes in subsurface soil and groundwater have the most potential to impact surface water. ~~However, to provide cleanup guidance, action levels for inorganics that may be of concern at RFETS are currently under development in a manner consistent with that used for VOCs.~~ > Working Group departed from this approach – See 2d paragraph of attached sheet for methodology.

The soil VOC levels necessary to be protective of groundwater were calculated using a soil/water partitioning equation and a calculated dilution factor (EPA 1994). The partitioning equation used chemical-specific parameters and site-specific subsurface media characteristics to determine the equilibrium partitioning of a given contaminant between the soil and groundwater. The dilution factor accounts for dilution up to the edge of the source location. Using this approach, subsurface

Also, action levels for rads in soils & for metals in subsurface soil will be completed by 10/18/96 (Hopefully!) What's your timeframe? We could include in App B as proposed ALs.

406

soil contaminant levels that would be protective of groundwater to 100 x MCLs were calculated (see Appendix B).

407

MEMO

Date: July 11, 1996

To: John Hopkins, Sitewide Actions, Bldg T893B, x4974

From: T.P. Lovseth, Sitewide Actions, Bldg T893B, x8249

Subject: Revised ASAP III Cost Estimate for Groundwater Remediation

The attached spreadsheets are cost estimates for the four groundwater plumes that will require remedial actions under ASAP III. All labor and capital line items are presented as unburdened costs. Detailed estimates were made for two different designs for each plume. The drain-sump design will capture groundwater at the distal portion of each plume by means of a subsurface filter-packed drain. Groundwater will be gravity fed from the drain to a sump and then pumped to the surface for treatment by air-stripping. The barrier-gate design will direct the natural flow of groundwater to a gate or sump. From the gate (sump), groundwater will be pumped to the surface for treatment by air stripping.

Included in the total costs are resources to fund characterization in support of remedial design. Assuming the local hydrogeologic conditions are not complex, each project will require about two weeks of geoprobe sampling activities to adequately characterize the horizontal and vertical extent of the plume boundaries. Because excavation will be required below the water table, all trenches will be shored to insure proper placement of the drain and filter pack.

We do not have a consensus on how effective the barriers will be. Under low hydraulic conductivity conditions, the barriers may cause water levels to rise resulting in mounding and ultimately, over-topping of the barriers. To ensure flow to the gates, shallow drains installed by ditch-witch equipment (to avoid the generation of waste) may be required. However, these shallow drains will not significantly effect the total costs. Given the present uncertainty of the hydraulic behavior of the barriers, I did not include the cost of the shallow drains in the estimates.

Drain installation will require a significant amount of excavation. For the purpose of this cost estimate, I assumed that only 10% of the removed soils will be contaminated and will require treatment by thermal desorption. The barrier-gate design is more expensive than the drain-sump design provided that the assumption made above regarding the amount of non-rad waste remains true. Also, we assume that we can perform thermal desorption for $1000/cubic yard. The sensitivity analysis shows that if the amount of waste or the cost to treat goes up, the barrier-gate design would then be the most cost effective option. I recommend that we keep both design options open until we determine the necessity and cost of treating excavated soils.

Please note that the capture length estimates presented for ASAP II have been revised. S. Joliat has re-estimated the capture length for each plume. A. Primrose has reviewed capture length and these cost estimates. Please call either A. Primrose (x4385) or myself (x8249) if you have any questions regarding this matter.

cc: A.L. Primrose
J.E. Law

408

ASAP PHASE III COST ESTIMATE FOR THE CARBON TETRACHLORIDE GROUNDWATER PLUME						
Drain-Sump						
	QUANTITY	UNIT COST		TOTAL COST	BASIS FOR QUANTITY	BASIS FOR UNIT COST*
CAPITAL						
Collection						
Earthwork/Trenching	1667	$3.77	cu.yd	$6,283	600 feet length x 25 feet depth x 3 feet width	Means Building Construction Cost Data
Shoring	30000	$11.15	sq.ft	$334,500	600 feet length x 25 feet depth x 2 sides	Means Building Construction Cost Data
Filter Pack - Sand	833	$9.25	cu.yd	$7,708	600 feet length x 12.5 feet depth x 3 feet width	Means Building Construction Cost Data
Filter Pack - Gravel	833	$8.75	cu.yd	$7,292	600 feet length x 12.5 feet depth x 3 feet width	Means Building Construction Cost Data
Sump	1	$3,788.00	ea.	$3,788	precast concrete 4 feet x 4 feet x 25 feet	Means Building Construction Cost Data
Pump	1	$1,850.00	ea.	$1,850	4-inch submersible	Means Building Construction Cost Data
Piping	600	$4.47	ft	$2,682	6-inch perf PVC	Means Building Construction Cost Data
Treatment						
Air Stripper	1	$8,000	ea.	$8,000		from "Options for GW Treatment..."
Poly Tank	1	$1,700	ea.	$1,700	2500 gallon	from "Options for GW Treatment..."
Concrete Pad	1	$2,000	ea.	$2,000	20 feet x 15 feet x 0.5 feet	from "Options for GW Treatment..."
Shed	1	$3,300	ea.	$3,300	20 feet x 15 feet x 10 feet	from "Options for GW Treatment..."
Equipment Installation	1	$3,200	ea.	$3,200		from "Options for GW Treatment..."
Electrical Supply and Installation	1	$5,000	ea.	$5,000		from "Options for GW Treatment..."
Plumbing	1	$300	ea.	$300		from "Options for GW Treatment..."
Characterization						
Geoprobe sampling	10	$900	day	$9,000	Subcontracted operator and H&S support	current billable rate for subcontracted svcs
Laboratory analysis	20	$377	ea.	$7,540		APO price schedule ver. 4 VOA 8240
Treat and dispose remediation wastes	167	$1,000	cu.yd	$166,667	Assumes 10% by volume of removed soil is contaminated	T-3 Thermal Desorb Costs, non-rad only
LABOR						
Engineering Design	775.2	$25	/hr	$19,380	15% of direct costs	Standard budgeting assumptions
Health and Safety	775.2	$25	/hr	$19,380	15% of direct costs	Standard budgeting assumptions
Construction Management	1550.4	$25	/hr	$38,760	30% of direct costs	Standard budgeting assumptions
Hydrogeologic Services	160.0	$25	/hr	$4,000	includes field supervision and data analysis	current billable rate
TOTAL CAPITAL AND LABOR				$652,331		
OPERATIONS AND MAINTENANCE						
Materials	1	$6,400	ea.	$6,400	repair and utilities	from "Options for GW Treatment..."
Laboratory Analysis	12	377	ea.	$4,524	performance monitoring	APO price schedule ver. 4 VOA 8240
Labor	324	$25	/hr	$8,100	3 days per month	from "Options for GW Treatment..."
YEARLY OPERATIONS AND MAINTENANCE				$19,024		

409

ASAP PHASE III COST ESTIMATE FOR THE MOUND GROUNDWATER PLUME						
Barrier-Gate						
	QUANTITY	UNIT COST		TOTAL COST	BASIS FOR QUANTITY	BASIS FOR UNIT COST*
CAPITAL						
Collection						
Waterloo Barrier	2448	$30.00	sq.ft	$73,440	204 feet length x 12 feet depth	Vendor quote
Sump	1	$1,981.00	ea.	$1,981	precast concrete 4 feet x4 feet x 12 feet	Means Building Construction Cost Data
Pump	1	$1,850.00	ea.	$1,850	4-inch submersible	Means Building Construction Cost Data
Treatment						
Air Stripper	1	$8,000	ea.	$8,000		from "Options for GW Treatment..."
Poly Tank	1	$1,700	ea.	$1,700	2500 gallon	from "Options for GW Treatment..."
Concrete Pad	1	$2,000	ea.	$2,000	20 feet x 15 feet x 0.5 feet	from "Options for GW Treatment..."
Shed	1	$3,300	ea.	$3,300	20 feet x 15 feet x 10 feet	from "Options for GW Treatment..."
Equipment Installation	1	$3,200	ea.	$3,200		from "Options for GW Treatment..."
Electrical Supply and Installation	1	$5,000	ea.	$5,000		from "Options for GW Treatment..."
Plumbing	1	$300	ea.	$300		from "Options for GW Treatment..."
Characterization						
Geoprobe sampling	10	$900	day	$9,000	Subcontracted operator and H&S support	current billable rate for subcontracted svcs
Laboratory analysis	20	$377	ea.	$7,540		APO price schedule ver. 4 VOA 8240
LABOR						
Engineering Design	201.5	$25	/hr	$5,039	15% of direct costs	Standard budgeting assumptions
Health and Safety	201.5	$25	/hr	$5,039	15% of direct costs	Standard budgeting assumptions
Construction Management	403.1	$25	/hr	$10,077	30% of direct costs	Standard budgeting assumptions
Hydrogeologic Services	160.0	$25	/hr	$4,000	includes field supervision and data analysis	current billable rate
TOTAL CAPITAL AND LABOR				$141,465		
OPERATIONS AND MAINTENANCE						
Materials	1	$6,400	ea.	$6,400	repair and utilities	from "Options for GW Treatment..."
Laboratory Analysis	12	377	ea.	$4,524	performance monitoring	APO price schedule ver. 4 VOA 8240
Labor	324	$25	/hr	$8,100	3 days per month	from "Options for GW Treatment..."
YEARLY OPERATIONS AND MAINTENANCE				$19,024		

ASAP PHASE III COST ESTIMATE FOR THE EAST TRENCHES GROUNDWATER PLUME						
Barrier-Gate						
	QUANTITY	UNIT COST		TOTAL COST	BASIS FOR QUANTITY	BASIS FOR UNIT COST*
CAPITAL						
Collection						
Waterloo Barrier	11808	$30.00	sq.ft	$354,240	984 feet length x 12 feet depth	Vendor quote
Sump	1	$1,981.00	ea.	$1,981	precast concrete 4 feet x4 feet x 12 feet	Means Building Construction Cost Data
Pump	1	$1,850.00	ea.	$1,850	4-inch submersible	Means Building Construction Cost Data
Treatment						
Air Stripper	1	$8,000	ea.	$8,000		from "Options for GW Treatment..."
Poly Tank	1	$1,700	ea.	$1,700	2500 gallon	from "Options for GW Treatment..."
Concrete Pad	1	$2,000	ea.	$2,000	20 feet x 15 feet x 0.5 feet	from "Options for GW Treatment..."
Shed	1	$3,300	ea.	$3,300	20 feet x 15 feet x 10 feet	from "Options for GW Treatment..."
Equipment Installation	1	$3,200	ea.	$3,200		from "Options for GW Treatment..."
Electrical Supply and Installation	1	$5,000	ea.	$5,000		from "Options for GW Treatment..."
Plumbing	1	$300	ea.	$300		from "Options for GW Treatment..."
Characterization						
Geoprobe sampling	10	$900	day	$9,000	Subcontracted operator and H&S support	current billable rate for subcontracted svcs
Laboratory analysis	20	$377	ea.	$7,540		APO price schedule ver. 4 VOA 8240
LABOR						
Engineering Design	763.1	$25	/hr	$19,079	15% of direct costs	Standard budgeting assumptions
Health and Safety	763.1	$25	/hr	$19,079	15% of direct costs	Standard budgeting assumptions
Construction Management	1526.3	$25	/hr	$38,157	30% of direct costs	Standard budgeting assumptions
Hydrogeologic Services	160.0	$25	/hr	$4,000	includes field supervision and data analysis	current billable rate
TOTAL CAPITAL AND LABOR				$478,425		
OPERATIONS AND MAINTENANCE						
Materials	1	$6,400	ea.	$6,400	repair and utilities	from "Options for GW Treatment..."
Laboratory Analysis	12	377	ea.	$4,524	performance monitoring	APO price schedule ver. 4 VOA 8240
Labor	324	$25	/hr	$8,100	3 days per month	from "Options for GW Treatment..."
YEARLY OPERATIONS AND MAINTENANCE				$19,024		

411

ASAP PHASE III COST ESTIMATE FOR THE 903 PAD HILLSIDE GROUNDWATER PLUME						
Barrier-Gate						
	QUANTITY	UNIT COST		TOTAL COST	BASIS FOR QUANTITY	BASIS FOR UNIT COST*
CAPITAL						
Collection						
Waterloo Barrier	10440	$30.00	sq.ft	$313,200	696 feet length x 15 feet depth	Vendor quote
Sump	2	$2,398.00	ea.	$4,796	precast concrete 4 feet x4 feet x 15 feet	Means Building Construction Cost Data
Pump	2	$1,850.00	ea.	$3,700	4-inch submersible	Means Building Construction Cost Data
Treatment						
Air Stripper	1	$8,000	ea.	$8,000		from "Options for GW Treatment..."
Poly Tank	1	$1,700	ea.	$1,700	2500 gallon	from "Options for GW Treatment..."
Concrete Pad	1	$2,000	ea.	$2,000	20 feet x 15 feet x 0.5 feet	from "Options for GW Treatment..."
Shed	1	$3,300	ea.	$3,300	20 feet x 15 feet x 10 feet	from "Options for GW Treatment..."
Equipment Installation	1	$3,200	ea.	$3,200		from "Options for GW Treatment..."
Electrical Supply and Installation	1	$5,000	ea.	$5,000		from "Options for GW Treatment..."
Plumbing	1	$300	ea.	$300		from "Options for GW Treatment..."
Characterization						
Geoprobe sampling	10	$900	day	$9,000	Subcontracted operator and H&S support	current billable rate for subcontracted svcs
Laboratory analysis	20	$377	ea.	$7,540		APO price schedule ver. 4 VOA 8240
LABOR						
Engineering Design	690.4	$25	/hr	$17,260	15% of direct costs	Standard budgeting assumptions
Health and Safety	690.4	$25	/hr	$17,260	15% of direct costs	Standard budgeting assumptions
Construction Management	1380.8	$25	/hr	$34,520	30% of direct costs	Standard budgeting assumptions
Hydrogeologic Services	160.0	$25	/hr	$4,000	includes field supervision and data analysis	current billable rate
TOTAL CAPITAL AND LABOR				$434,775		
OPERATIONS AND MAINTENANCE						
Materials	1	$6,400	ea.	$6,400	repair and utilities	from "Options for GW Treatment..."
Laboratory Analysis	12	377	ea.	$4,524	performance monitoring	APO price schedule ver. 4 VOA 8240
Labor	324	$25	/hr	$8,100	3 days per month	from "Options for GW Treatment..."
YEARLY OPERATIONS AND MAINTENANCE				$19,024		

4/12

ASAP PHASE III COST ESTIMATE FOR THE CARBON TETRACHLORIDE GROUNDWATER PLUME						
Barrier-Gate						
	QUANTITY	UNIT COST		TOTAL COST	BASIS FOR QUANTITY	BASIS FOR UNIT COST*
CAPITAL						
Collection						
Waterloo Barrier	15000	$30.00	sq.ft	$450,000	600 feet length x 25 feet depth	Vendor quote
Sump	1	$3,788.00	ea.	$3,788	precast concrete 4 feet x4 feet x 25 feet	Means Building Construction Cost Data
Pump	1	$1,850.00	ea.	$1,850	4-inch submersible	Means Building Construction Cost Data
Treatment						
Air Stripper	1	$8,000	ea.	$8,000		from "Options for GW Treatment..."
Poly Tank	1	$1,700	ea.	$1,700	2500 gallon	from "Options for GW Treatment..."
Concrete Pad	1	$2,000	ea.	$2,000	20 feet x 15 feet x 0.5 feet	from "Options for GW Treatment..."
Shed	1	$3,300	ea.	$3,300	20 feet x 15 feet x 10 feet	from "Options for GW Treatment..."
Equipment Installation	1	$3,200	ea.	$3,200		from "Options for GW Treatment..."
Electrical Supply and Installation	1	$5,000	ea.	$5,000		from "Options for GW Treatment..."
Plumbing	1	$300	ea.	$300		from "Options for GW Treatment..."
Characterization						
Geoprobe sampling	10	$900	day	$9,000	Subcontracted operator and H&S support	current billable rate for subcontracted svcs
Laboratory analysis	20	$377	ea.	$7,540		APO price schedule ver. 4 VOA 8240
LABOR						
Engineering Design	958.3	$25	/hr	$23,957	15% of direct costs	Standard budgeting assumptions
Health and Safety	958.3	$25	/hr	$23,957	15% of direct costs	Standard budgeting assumptions
Construction Management	1916.6	$25	/hr	$47,914	30% of direct costs	Standard budgeting assumptions
Hydrogeologic Services	160.0	$25	/hr	$4,000	includes field supervision and data analysis	current billable rate
TOTAL CAPITAL AND LABOR				$595,506		
OPERATIONS AND MAINTENANCE						
Materials	1	$6,400	ea.	$6,400	repair and utilities	from "Options for GW Treatment..."
Laboratory Analysis	12	377	ea.	$4,524	performance monitoring	APO price schedule ver. 4 VOA 8240
Labor	324	$25	/hr	$8,100	3 days per month	from "Options for GW Treatment..."
YEARLY OPERATIONS AND MAINTENANCE				$19,024		

413

Table E-8. Alternative7: Soil Excavation and Groundwater Removal With Sump Pumps

Soil will be treated on site and placed back into origional excavation

				Bare Costs Per Unit					Bare Costs				
Activity	Resource Description	Qty.	Unit	Mat'l	Equip.	Labor	Sub-contract	Source	Mat'l	Equip.	Labor	Sub-contract	Total Costs
Direct Capital Costs													
Construct Staging Area	Towed Sheepsfoot	404	CY		$0.70	$0.20		Means Ref.	$0	$283	$81	$0	$364
	Base Course	1003	SY	$2.12	$0.29	$0.22		Means Ref.	$2,126	$291	$221	$0	$2,638
	Reinforced Concrete Slab, 6" Thick	0	CY	$88.28	$9.09	$72.52		Means Ref.	$0	$0	$0	$0	$0
	Submersible Sump Pump, 5 gpm	0	ea		$300.00			Vendor Quote	$0	$0	$0	$0	$0
	2" PVC Piping (including fittings)	0	lf	$1.44		$2.04		Means Ref.	$0	$0	$0	$0	$0
Scrape Top Soil & Stockpile	Towed Scraper	323	CY		$3.45	$0.81		Means Ref.	$0	$1,114	$262	$0	$1,376
Dust Control	Water Truck, 5,000 gal capacity	1,440	hr		$21.32	$25.00		Means Ref.	$0	$30,701	$36,000	$0	$66,701
Excavate Soil, Haul to Staging Area	Dozer	1,400	CY		$2.91	$0.64		Means Ref.	$0	$4,074	$896	$0	$4,970
	Backhoe	0	CY		$0.98	$0.37		Means Ref.	$0	$0	$0	$0	$0
	Front End Loader	1,400	CY		$0.66	$0.35		Means Ref.	$0	$924	$490	$0	$1,414
	Dump Trailer	1,400	CY		$1.15	$0.46		Means Ref.	$0	$1,610	$644	$0	$2,254
Dewatering	20 gpm Suction Pumps	2	ea		$400.00			Vendor Quote	$0	$800	$0	$0	$800
	2.5" PVC Pipe (includes fittings)	200	lf	$1.70		$2.19		Means Ref.	$340	$0	$438	$0	$778
	Corrugated Metal Pipe	12	lf	$4.15		$1.40		Means Ref.	$50	$0	$17	$0	$67
	Pea Gravel	30	CY	$17.55				Means Ref.	$527	$0	$0	$0	$527
Rad Screening of Soils	Health & Safety Specialist	1,440	hr			$56.00		EG&G Rad Eng.	$0	$0	$80,640	$0	$80,640
	Monitoring Equipment Maintenance	180	hr			$55.00		EG&G Rad Eng.	$0	$0	$9,900	$0	$9,900
Treatment of Excavated Soils	Thermal Desorption Unit	1,400	CY				$75.00	Vendor Quote	$0	$0	$0	$105,000	$105,000
	Thermal Desorption Unit Mobilization	1	ls				$4,000.00	Vendor Quote	$0	$0	$0	$4,000	$4,000
	Thermal Desorption Unit Demobilization	1	ls				$1,500.00	Vendor Quote	$0	$0	$0	$1,500	$1,500
	Wheel Mounted Front End Loader	2,800	CY		$0.66	$0.35		Means Ref.	$0	$1,848	$980	$0	$2,828
Transportation/Disposal of Soil	Transportation to Disposal Facility (< 50 mi)	0	CY				$53.00	Vendor Quote	$0	$0	$0	$0	$0
	Disposal at Licensed Facility	0	CY				$123.00	Vendor Quote	$0	$0	$0	$0	$0
	Soil Samples	0	ea				$250.00	Prof. Judgement	$0	$0	$0	$0	$0
Groundwater Treatment	UV/Peroxide & IX Treatment System	1	yr				$676,000.00	(1)	$0	$0	$0	$676,000	$676,000
Backfill Excavation	Pit-Run Fill/Gravel, 5 mi haul	0	CY	$3.57	$4.86	$1.83		Means Ref.	$0	$0	$0	$0	$0
	Towed Sheepsfoot, 12" lifts	0	CY		$0.35	$0.09		Means Ref.	$0	$0	$0	$0	$0
	Revegitation	2,904	SY	$0.22	$0.06	$0.06		Means Ref.	$639	$174	$174	$0	$987
Decommission French Drain	Backhoe	1	day		$2,200	$362.00		Means Ref.	$0	$2,200	$362	$0	$2,562
Drill Monitoring Wells	Drill & Case 4 wells, 6"diam. & 20'depth	4	ea				$25,000.00	Vendor Quote	$0	$0	$0	$100,000	$100,000
Additional Field Personnel	Sr. Geologist	110	hrs			$75.00		Prof. Judgement	$0	$0	$8,250	$0	$8,250
	Surveyor	100	hrs			$50.00		Prof. Judgement	$0	$0	$5,000	$0	$5,000
Confirmatory Sampling	Soil Samples From Excavation Site	25	ea				$250.00	Prof. Judgement	$0	$0	$0	$6,250	$6,250
Subtotal Direct Capital Costs									$3,682	$44,019	$144,354	$892,750	$1,073,555
Indirect Capital Costs													
Engineering, Design & Inspection	15% of direct materials, equipment, & labor							Facil. Eng. 009	$552	$6,603	$21,653	$0	$28,808
Miscellaneous Labor & Materials	10% of direct labor & $1.50 in materials cost for each direct labor hour							Facil. Eng. 009	$8,403	$0	$14,435	$0	$22,838
Permits	5% of direct materials, equipment, & labor							Prof. Judgement	$184	$2,201	$7,218	$0	$9,603
Construction Management	10% of direct materials, equipment, & labor							Prof. Judgement	$368	$4,402	$14,435	$0	$19,205
Project Management	10% of direct materials, equipment, & labor + ED&I							EG&G Cost Est.	$423	$5,062	$16,601	$0	$22,086
Overhead, Profit & Bond	25.3% of direct materials, equipment, & labor							Facil. Eng. 009	$931	$11,137	$36,522	$0	$48,590
Subcontractor Fee	10% of subcontractor costs							Facil. Eng. 009	$0	$0	$0	$89,275	$89,275
Subtotal Indirect Capital Costs									$10,862	$29,405	$110,864	$89,275	$240,406

414

Activity	Resource Description	Qty.	Unit	Bare Costs Per Unit				Source	Bare Costs				Total Costs
				Mat'l	Equip.	Labor	Sub-contract		Mat'l	Equip.	Labor	Sub-contract	
Contingency	30% of direct and indirect capital costs							Facil. Eng. 009	$4,363	$22,027	$76,565	$294,608	$397,563
Total Capital Costs									$18,907	$95,451	$331,784	$1,276,633	$1,722,774
Annual O&M Direct Costs													
Subtotal O&M Direct Costs									$0	$0	$0	$0	$0
Total O&M Costs									$0	$0	$0	$0	$0
Annual Post Closure Direct Costs													
Semiannual Sampling	Collect Groundwater Samples	12	ea				$1,500.00	Prof. Judgement	$0	$0	$0	$18,000	$18,000
Groundwater Monitoring	Semiannual Groundwater Sampling	14	ea				$4,100.00	Vendor Quote	$0	$0	$0	$57,400	$57,400
Revegitation	10% of Excavated Area/yr	290	SY	$0.22	$0.06	$0.06		Means Ref.	$64	$17	$17	$0	$99
Subtotal Post Closure Direct Costs									$64	$17	$17	$75,400	$75,499
Annual Post Closure Indirect Costs													
Project Management	10% of post closure direct materials, equipment, & labor costs							EG&G Cost Est.	$6	$2	$2	$0	$10
Subcontractor Fee	10% of post closure subcontractor costs							Facil. Eng. 009	$0	$0	$0	$7,540	$7,540
Subtotal Post Closure Indirect Costs									$6	$2	$2	$7,540	$7,550
Contingency	30% of total post closure direct and inderect costs							Facil. Eng. 009	$21	$6	$6	$24,882	$24,915
Total Annual Post Closure Costs									$91	$25	$25	$107,822	$107,963
Total Post Closure Costs (30 yr @ 5% discount rate)									$1,494	$407	$407	$1,765,310	$1,767,619
Total Cost Of Alternative									$20,401	$95,858	$332,191	$3,041,943	$3,490,393

(1) Cost represents annual operating cost as presented in the Phase I Preliminary Plan for Future Utilization of Existing Water Treatment Facilities at Rocky Flats Plant, Draft Report (June 15, 1994).
It has been assumed for cost estimating purposes that the French Drain and OU-1 Water Treatment Plant will operate for one year during excavation and treatment.

415

Sensitivity Analysis					
	Treated		Cost of		
	Volume		Treatment by	Cost w/o soil	Total
Plume	cu.yd	Cost/cu.yd	Therm Desorb	treatment	Cost
DRAIN-SUMP					
mound	272	$ 1,000	$ 272,000	$ 100,607	$ 372,607
east trenches	1310	$ 1,000	$ 1,310,000	$ 281,346	$ 1,591,346
903 pad hillside	1160	$ 1,000	$ 1,160,000	$ 285,904	$ 1,445,904
carbon tetrachloride	1670	$ 1,000	$ 1,670,000	$ 485,664	$ 2,155,664
mound	272	$ 1,495	$ 406,640	$ 100,607	$ 507,247
east trenches	1310	$ 1,495	$ 1,958,450	$ 281,346	$ 2,239,796
903 pad hillside	1160	$ 1,495	$ 1,734,200	$ 285,904	$ 2,020,104
carbon tetrachloride	1670	$ 1,495	$ 2,496,650	$ 485,664	$ 2,982,314
mound	27.2	$ 1,000	$ 27,200	$ 100,607	$ 127,807
east trenches	131	$ 1,000	$ 131,000	$ 281,346	$ 412,346
903 pad hillside	116	$ 1,000	$ 116,000	$ 285,904	$ 401,904
carbon tetrachloride	167	$ 1,000	$ 167,000	$ 485,664	$ 652,664
mound	27.2	$ 1,495	$ 40,664	$ 100,607	$ 141,271
east trenches	131	$ 1,495	$ 195,845	$ 281,346	$ 477,191
903 pad hillside	116	$ 1,495	$ 173,420	$ 285,904	$ 459,324
carbon tetrachloride	167	$ 1,495	$ 249,665	$ 485,664	$ 735,329
BARRIER-GATE					
mound	0	$ -	$ -	$ 141,465	$ 141,465
east trenches	0	$ -	$ -	$ 478,425	$ 478,425
903 pad hillside	0	$ -	$ -	$ 434,775	$ 434,775
carbon tetrachloride	0	$ -	$ -	$ 595,506	$ 595,506

2C106

TELEPHONE LOG

RECORDED BY: A. L. PRIMROSE

NAME: Ann Sieben	OF: K-H	HONE: 9886
DATE: 9/26	TIME: 11 am	

SUBJECT: Draft Groundwater Conceptual Plan

CONVERSATION:

She read chapter 4 of this report and thinks it's fine. She had minor comments, "itty-bitty little things, not even worth saying". (No comments were provided). She said that it sounds real good, reads fairly well, and she thinks it's everything it needs to be.

FOLLOW-UP: None

417

INTEROFFICE CORRESPONDENCE

AS Sent 4-14-94 BJR

DATE: April 14, 1994

TO: P. J. Suniewick, Ext. X2889

FROM: B. L. Roberts, Ext. X8623

SUBJECT: CONTAMINATED GROUNDWATER ESTIMATE UPDATE

The following analysis is provided in response to your request for estimates of total volumes of contaminated groundwater at the Rocky Flats Plant (RFP). The techniques used for this estimate differ from those previously employed. The techniques used this year should provide a more accurate estimate of the total current volume of contaminated groundwater at the RFP.

The volume estimates presented here are based on two primary sources of information. The first source of information are maps, and corresponding data grids showing the bedrock and groundwater elevations for the spring of 1992 (this period was chosen since it was a time of relatively high groundwater elevations). The second source of information is the Draft Well Evaluation Report (WER) which contains maps of the extent of groundwater contamination for different analyte combinations at the RFP. The production of this report is being directed by Steve Singer (Geosciences, X8635). Five of these analyte combination maps were superimposed over one another to obtain a map showing the total extent of groundwater contamination regardless of analyte. This final map shows a composite of the individual areas considered a concern for: *alpha and beta radiation, plutonium, americium, lithium, selenium, total dissolved solids (TDS), nitrate, sulfate, and volatile organic compounds (VOC)*. The final map is shown in Figure 1. Please note that not all of these contaminants are of concern for all of the areas outlined in Figure 1.

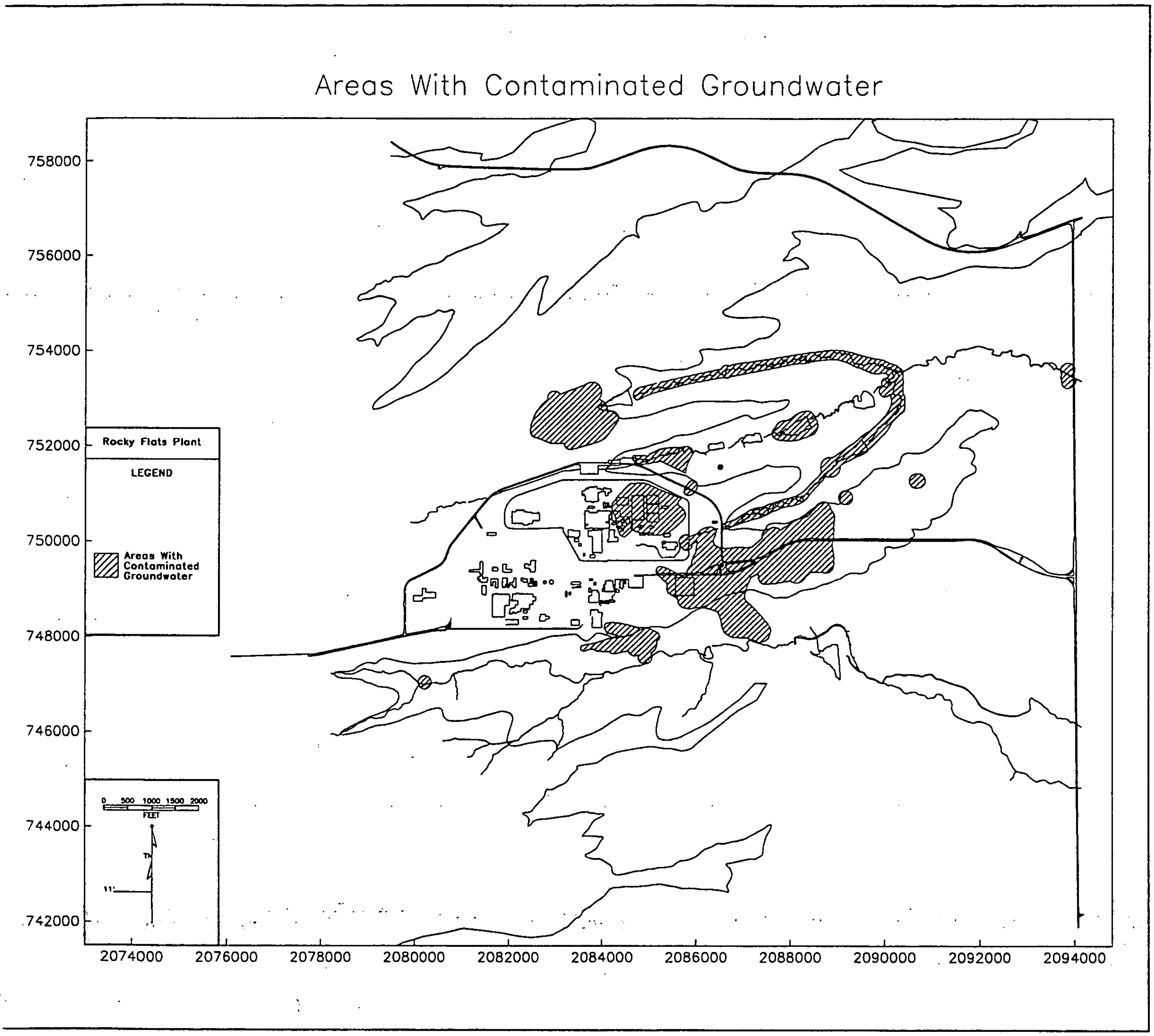
An estimate of the total volume of water saturated materials lying within the hachured areas shown in Figure 1 was made using the bedrock and spring 1992 groundwater elevation grids (at 100' spacing), the polygons representing the contaminated areas, and the Dynamic Graphics volumetrics modeling software package. These calculations only involve the unconsolidated surficial materials and do not consider bedrock materials. The total volume from all of the individual contaminated areas was then multiplied by an assumed effective porosity to get the total volume of contaminated water.

Total Vol.		Porosity		Water Vol.
71,712,000 ft^3	**x**	**0.1**	**=**	**<u>7,171,200 ft^3</u>**

Water Vol.		Gal./Ft^3		Water Vol.
7,171,200 ft^3	**x**	**7.48**	**=**	**<u>53,640,576 gallons</u>**

418

Figure 1



Areas With Contaminated Groundwater
Rocky Flats Plant
LEGEND
Areas With Contaminated Groundwater
0 500 1000 1500 2000
FEET
758000
756000
754000
752000
750000
748000
746000
744000
742000
2074000
2076000
2078000
2080000
2082000
2084000
2086000
2088000
2090000
2092000
2094000

419

The volume estimates for each individual region shown in Figure 1 are also available if needed. This estimate is approximately twice as large as the previous estimate. This is because of different methodologies and increased data availability. The previous estimate was related to the amount of water flowing though the OU's over a period of one year. The volumes reported here represent the amount of water contained within the contaminated regions identified in the WER as if it were possible to extract all the water at one time. These regions represent the maximum extent of contamination, as determined from groundwater sampling, from either 1990 or 1992, which ever was greater. Details of the techniques used to identify these areas can be found in the text of the WER.

As a reminder, because of the interaction between the solid and liquid phases (adsorption/desorption) for some contaminants, the actual volume of groundwater that would have to be pumped and treated to clean up these locations would be much larger than the estimates provided here. The volumes listed above are those that would be encountered if it were physically possible to instantly remove the all contaminated waters.

In addition, this estimate does not consider the effects of interim-remediation activities, such as the OU-1 French Drain system. If it is desirable to attempt to include the influence of this system, the contaminated region associated with OU-1 could easily be removed from the calculations.

Please let me know if further clarification is needed on any of these items,

Barry L. Roberts

RMRS Rocky Mountain Remediation Services, L.L.C
... protecting the environment

Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, Colorado 80402-0464
Phone: (303) 966-2677
Fax (303) 966-8244

DATE: August 16, 1995

TO: Subcontract File

FROM: C. Dains, RMRS Procurement, Bldg. 080, X8512

SUBJECT: NEGOTIATION PLAN FOR THE DEVELOPMENT OF OU CONSOLIDATION AND GROUNDWATER STRATEGIES

1. INTRODUCTION

The objective of this subcontract is to produce strategy documents for the consolidation of Operable Units at the Rocky Flats Environmental Technology Site (RFETS) and for examining treatment options for site wide groundwater problems.

2. COST/PRICE SUMMARY

TASK 1 - Operable Unit Consolidation

	Proposed	Objective	Upper Limit
Labor	7,747	3,296	3,296
ODC's	150	150	150
Subcontractors	26,813	20,933	23,873
Subtotal	34,710	24,379	27,319

TASK 2 - Sitewide Groundwater Treatment Strategy

	Proposed	Objective	Upper Limit
Labor	10,670	8,546	8,546
ODC's	188	188	188
Subcontractors	25,840	21,491	23,665
Subtotal	36,698	30,225	30,399
GRAND TOTAL	71,408	54,604	59,718

It should be noted at this point that the Subcontractor proposed only Sr. Geologist hours and did not propose any Program Manager hours for either Task 1 or Task 2. In the Technical Evaluation, it was determined by the Contractor Technical Representative that the Sr. Geologist was also performing the duties of the Program Manager. Therefore, Schedule B will reflect a labor category for both a Program Manager for Task 1 and 2 and a Sr. Geologist for Task 2 only.

421

3. NEGOTIATION ISSUES

Labor Hours - The labor categories proposed for Program Manager and Sr. Geologist have been explained above. The negotiating issues under this section will pertain to the proposed labor hours as well as the labor categories. The following distribution for the labor hours and categories are as follows:

TASK 1	Proposed	Objective	Upper Limit
Program Manager	0	35	35
Sr. Geologist	72	0	0
TASK 2			
Program Manager	0	35	35
Sr. Geologist	104	40	40

All though there was no labor category or hours proposed for a Program Manager and the fact that all the total proposed hours were to support a Sr. Geologist, an overall reduction in labor hours of 66 hours is realized based on the recommendation presented in the Technical Evaluation. The same rate of $73.18 is being used for both labor categories.

Subcontractor Hours - There are two Subcontractors proposed to support the requirements of the statement of work. Two subcontractors are ERM Program Management Company providing the Senior Engineer and Jason Associates Corporation providing the Senior Scientist. The hours proposed for both Subcontractors were considered excessive and the following recommendations were made in the technical evaluation.

TASK 1	Proposed	Objective	Upper Limit
Sr. Engineer (ERM)	72	40	56
Sr. Scientist (Jason)	232	200	216
TASK 2			
Sr. Engineer (ERM)	124	80	102

The upper limit for both Task 1 and Task 2 was established by the Subcontract Administrator to allow for information that may be presented at the time of negotiations that was not clearly expressed in the formal proposal. No adjustments will be made to the objective position without the full consent of the technical representative who will be present at the time of negotiations.

422

4. CONCLUSION

The objective position has been established at $54,604 with an upper limit of $59,718. The recommended objective position is considered fair and reasonable based on the technical evaluation and the cost estimate provided by the Contractors Technical Representative. Price reasonableness has been established based on the Price/Cost Analysis filed under Tab C-3. It is the Subcontract Administrator's recommendation that a negotiated award between the objective and upper limit position would be in the best interest of RMRS and the Government.

423

Received: AUGUST 15, 1995 08:53 **Sent:** AUGUST 15, 1995 08:50
From: KLONDON.EGG <KLONDON.EGG>
To: APRIMROSE.EGG
Subject: Re: ITS WATER
In-Reply-To: APRIMROSE.EGG's message of 15-Aug-95 08:00

Steve Singer had expressed distress to me a couple months ago about the wells - that the site-wide $ had been cut and vital wells "hidden" in OUs, but then (since they weren't really vital to those OUs) they got cut altogether. He was worried that people thought those wells were still funded and they weren't. I don't know if Steve can help, but he could worry on you.

Kathy

---- Included Message ----

Received: AUGUST 15, 1995 07:03 **Sent:** AUGUST 15, 1995 07:02
From: APRIMROSE.EGG <APRIMROSE.EGG>
To: KLONDON.EGG
Subject: Re: ITS WATER
In-Reply-To: KLONDON.EGG's message of 14-Aug-95 13:28

Hi Kathy! Thanks for the message. Are we still sampling wells in the vicinity of the ITS? John was curious if we have a way of picking up a groundwater plume, if one is moving through, without the ITS data. Who can I talk to?

Thanks.

ALP

---- Included Message ----

Received: AUGUST 14, 1995 13:30 **Sent:** AUGUST 14, 1995 13:28
From: KLONDON.EGG <KLONDON.EGG>
To: JLAW(John Law)
Subject: ITS WATER
Cc: andy, APRIMROSE(Annette Primrose)

John: FYI

In FY96, Rick Dunn in WM will handle the Interceptor Trench System and Central Sump for the Solar Ponds. He called, not sure who to talk to, to let ER know he will *not* continue the quarterly samples from the sump.

There was no regulatory driver for those quarterly samples that I recall: we were interested if we could detect a decreasing trend in contaminants and were just generally interested in the results. Someday, it may be sensible to delist the water or otherwise prove it no longer contains hazardous waste. There could be a big cost savings there if we could actually stop treatment; the water would end up in the buffer zone ponds so whether we could stop treatment would depend on how the water would effect the NPDES discharge compliance.

If you were counting on those quarterly samples for anything, we will need to sort out a different funding mechanism.

Kathy

----- End of Message -----

424

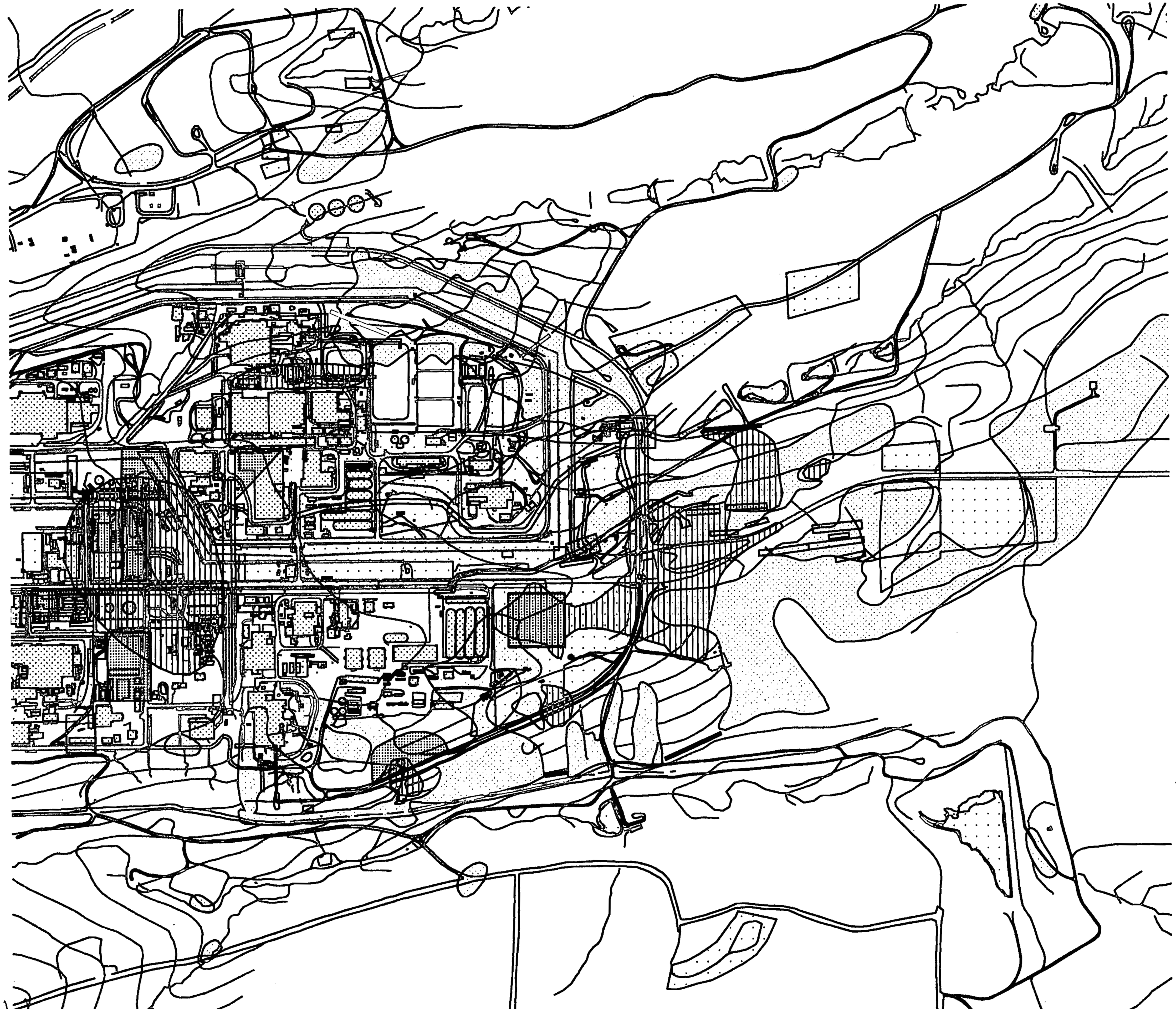
Author: John Law at ALPHA10
Date: 07/02/96 08:15 AM
Priority: Normal
TO: Annette Primrose
TO: John Hopkins at MAIL1
Subject: Groundwater Conceptual Plan

------------------------------------ Message Contents ------------------------------------

I just got off the phone with Ravi Batra. The based on concerns expressed by EPA and State on closure of OUs 5 & 6 we need to explicitly state that seeps will be remediated as part of the groundwater strategy. We should probably say that contaminated seeps are simply the most distal end of groundwater plumes. They will be managed through cleanup of groundwater sources, natural attenuation, interception at or upgradient of seep locations in accordance with the ALF and the prioritization system.

951199
951857

425



Potential Remedial Actions with Composite Plume Extent for Concentrations > 100x MCLs

Contamination extent boundaries represent groundwater sampling results for TCE, PCE, CCl4, and VC

- Rb.shp
- Suspected_Voa_sources
- 100 MCL in GW
- Q293 GW El
- Impervious
- Unpaved
- Surface_hydro
- Ihss
- Buildings
- Q293_dry

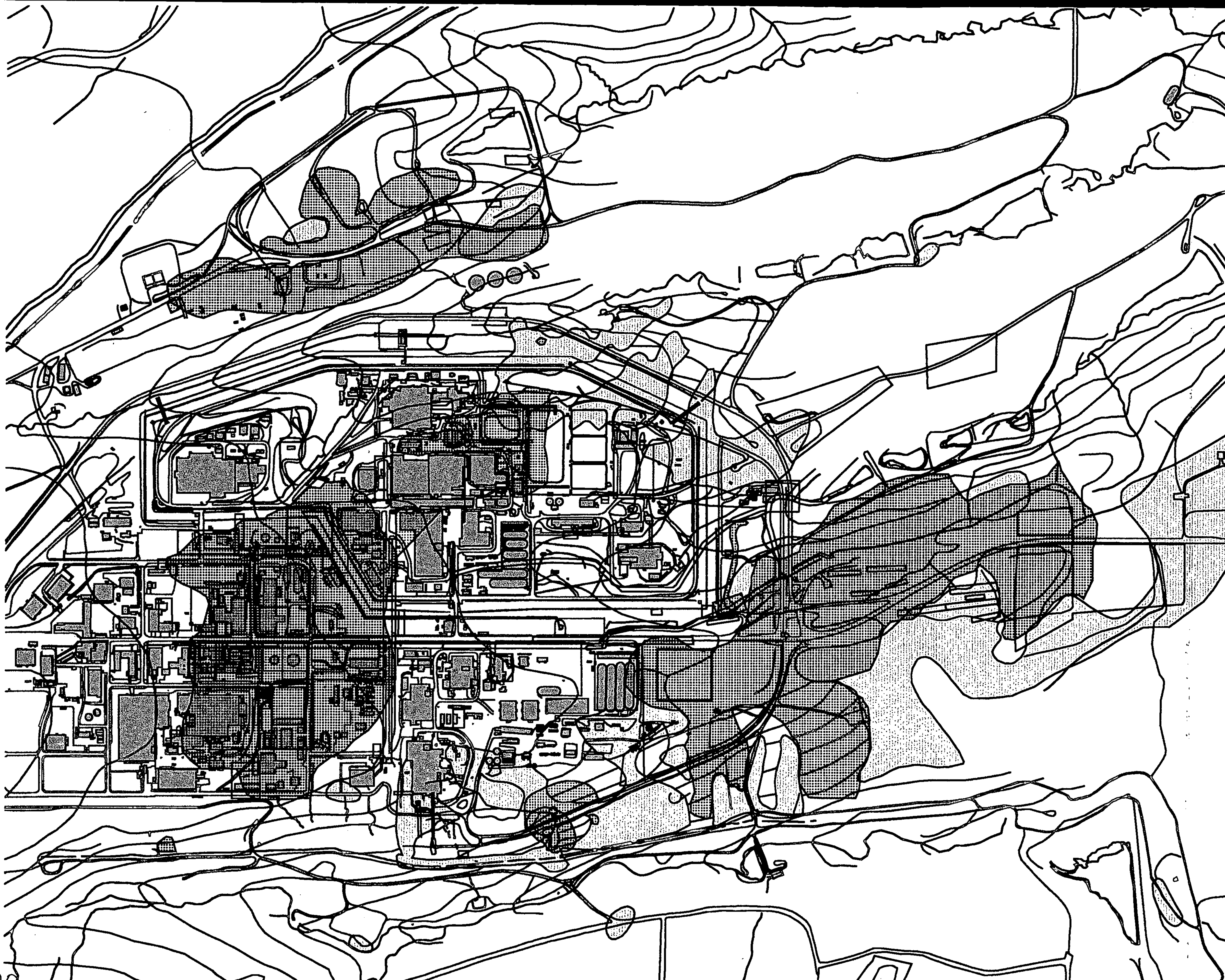
N

0 450 Feet

Figure 4-1

same problems as Fig 3-1

381 381



Composite VOC Plume Extent for Concentrations > MCL

Contamination extent boundaries represent groundwater sampling results for TCE, PCE, CCl4, and VC

define

?

Q293 GW El

Conc > MCL

Suspected_Voa_sources

Unpaved

?

Surface_hydro

Impervious

Ihss

Buildings

Q293_dry

?

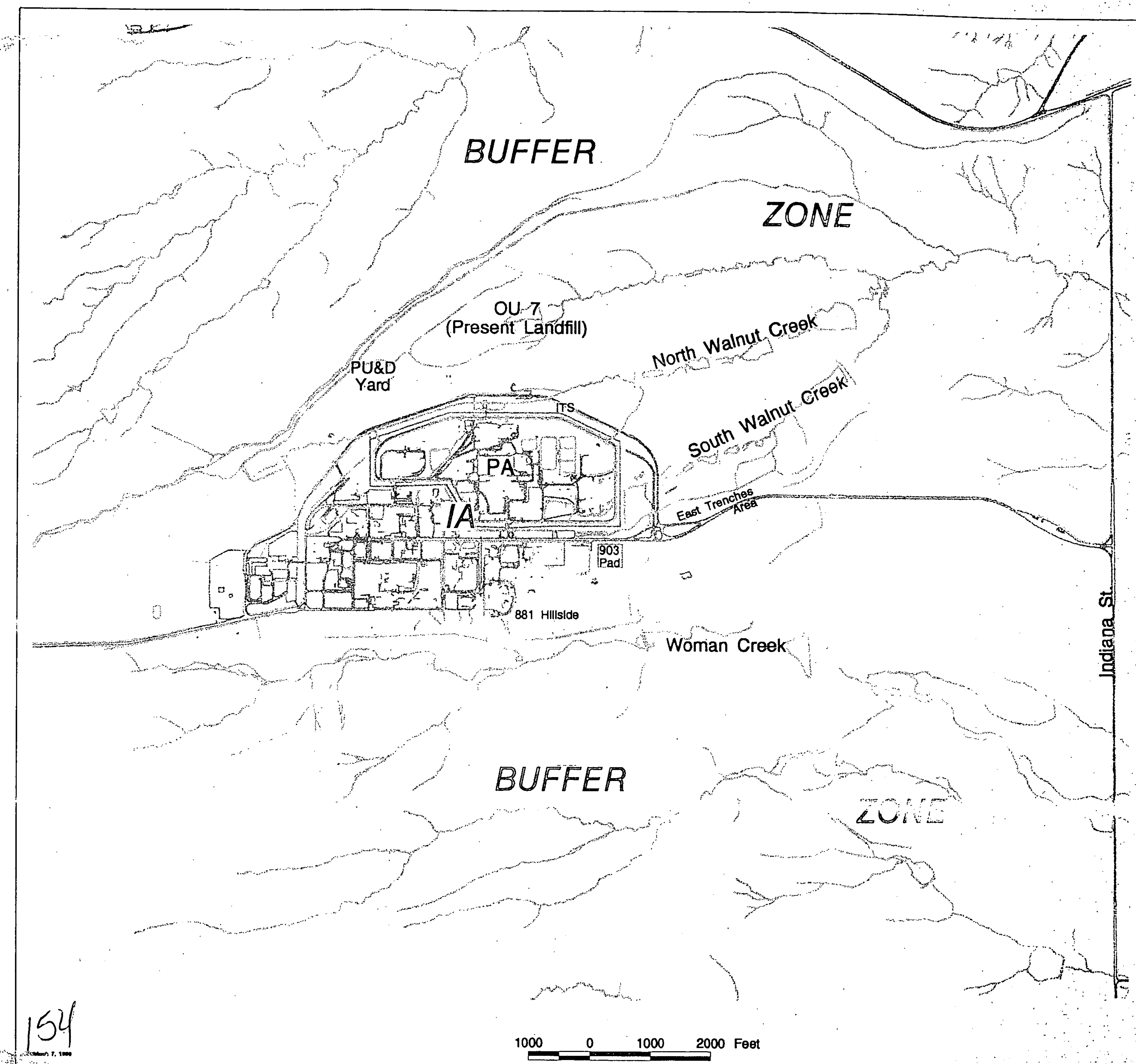
Unsaturated areas

N

too busy

Figure 3-1

380



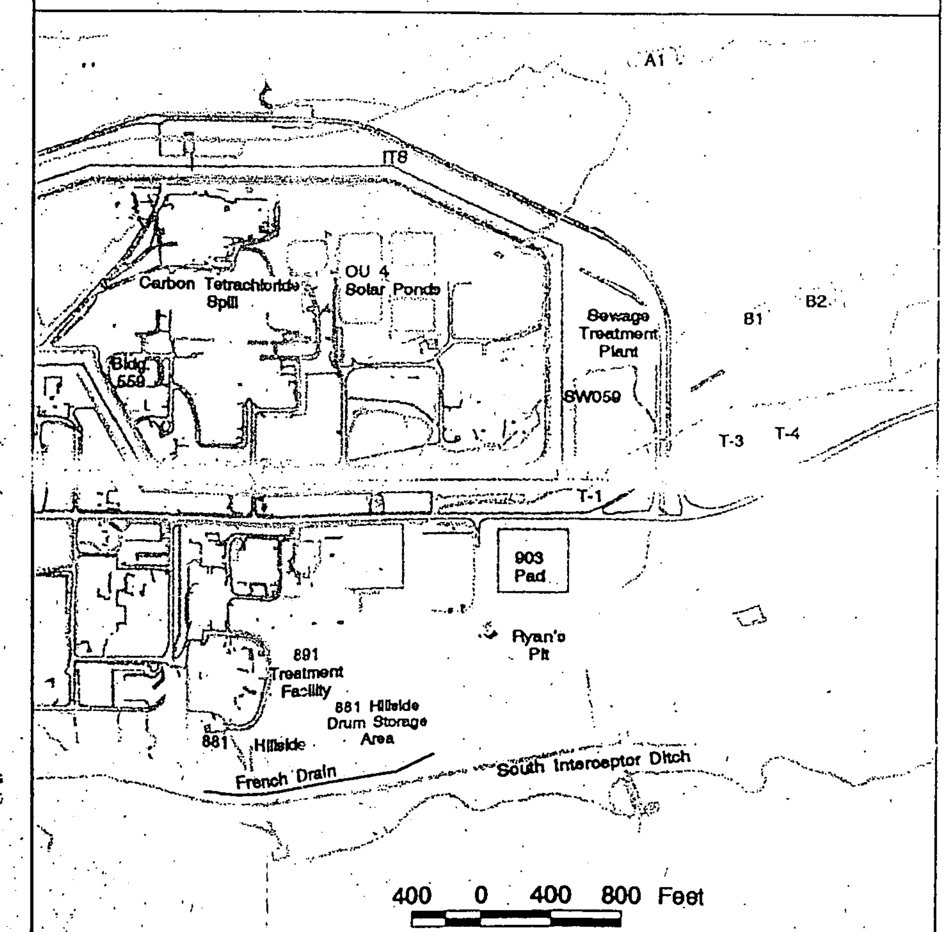
Location Reference Map

Location of areas of interest refered to in text.

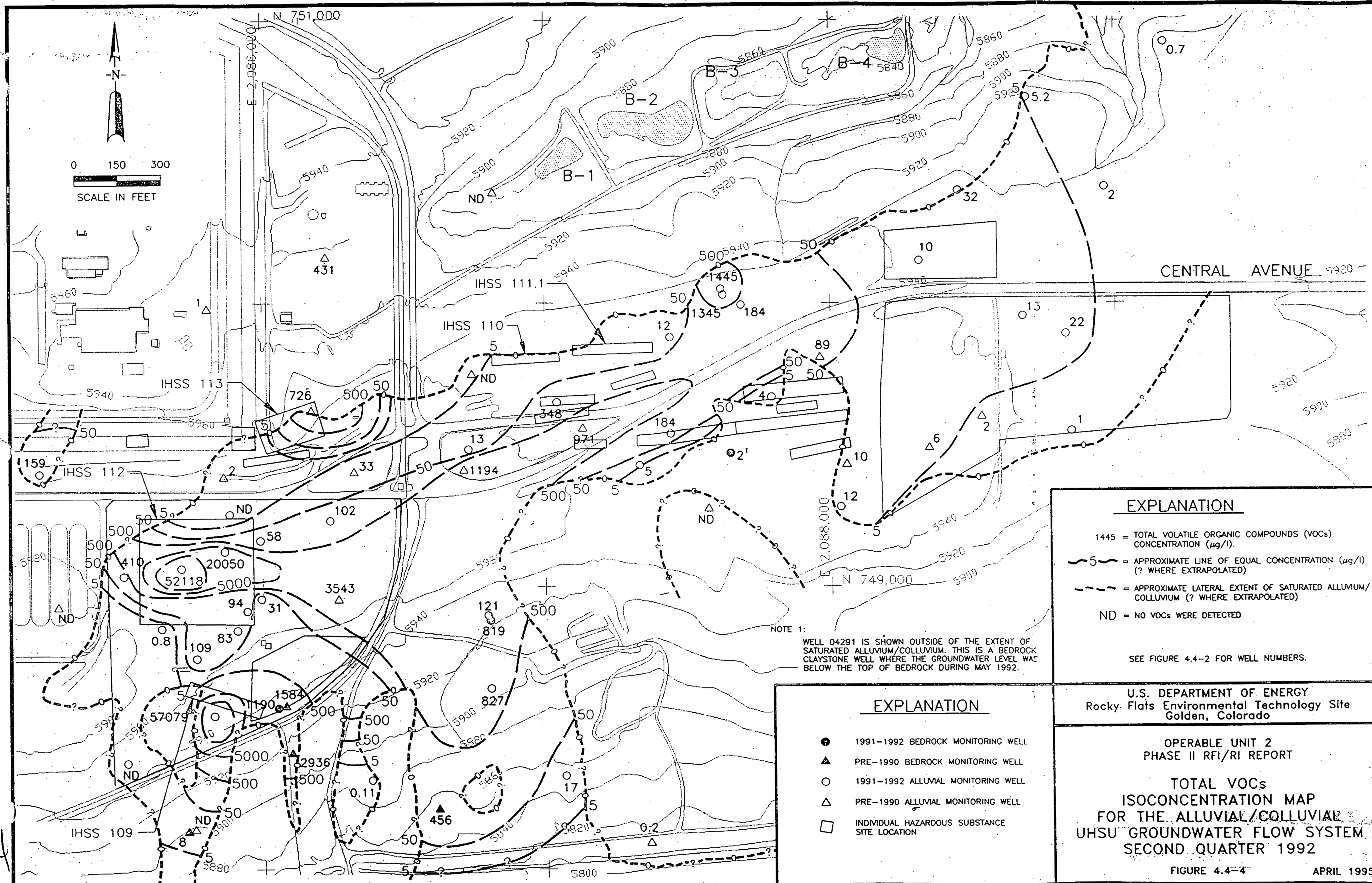
Figure 1-1

N

Detailed View of East Side of Plant Site

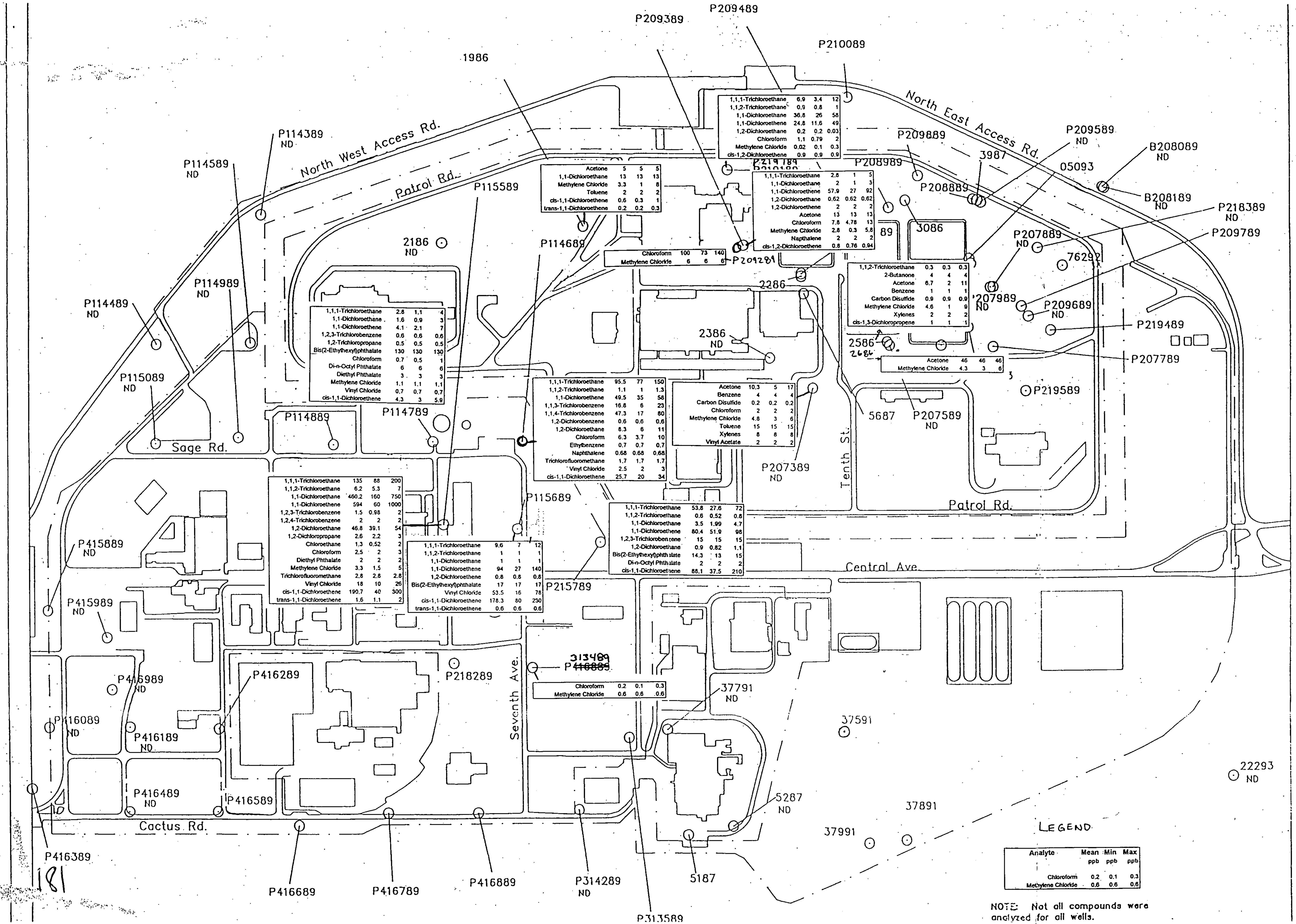


154

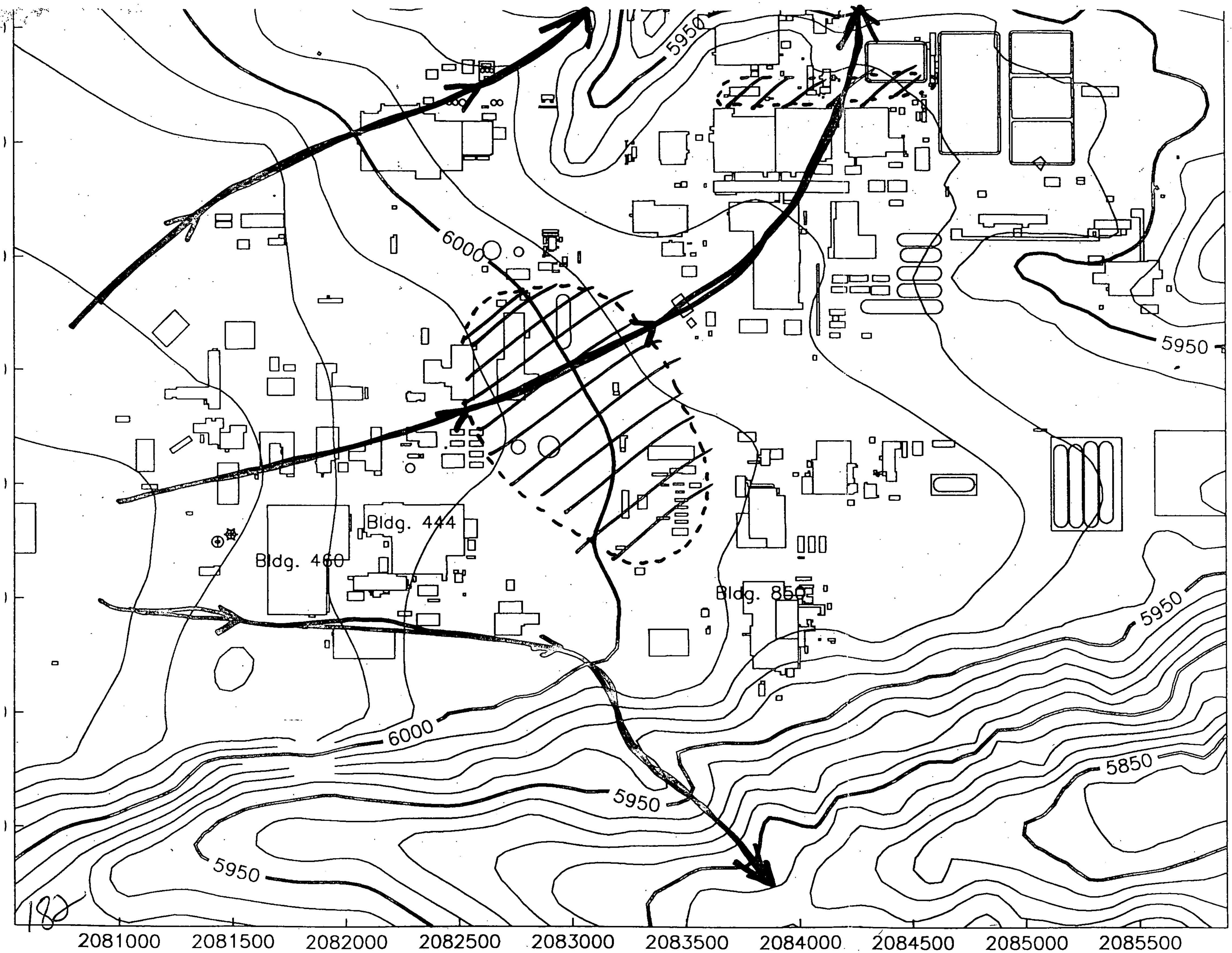


-N-
0 150 300
SCALE IN FEET
N 751,000
E 2,086,000
N 749,000
E 2,088,000
CENTRAL AVENUE
B-1
B-2
B-3
B-4
IHSS 111.1
IHSS 110
IHSS 113
IHSS 112
IHSS 109
NOTE 1:
WELL 04291 IS SHOWN OUTSIDE OF THE EXTENT OF SATURATED ALLUVIUM/COLLUVIUM. THIS IS A BEDROCK CLAYSTONE WELL WHERE THE GROUNDWATER LEVEL WAS BELOW THE TOP OF BEDROCK DURING MAY 1992.
EXPLANATION
1445 = TOTAL VOLATILE ORGANIC COMPOUNDS (VOCs) CONCENTRATION (µg/l).
5 = APPROXIMATE LINE OF EQUAL CONCENTRATION (µg/l) (? WHERE EXTRAPOLATED)
= APPROXIMATE LATERAL EXTENT OF SATURATED ALLUVIUM/COLLUVIUM (? WHERE EXTRAPOLATED)
ND = NO VOCs WERE DETECTED
SEE FIGURE 4.4-2 FOR WELL NUMBERS.
EXPLANATION
1991-1992 BEDROCK MONITORING WELL
PRE-1990 BEDROCK MONITORING WELL
1991-1992 ALLUVIAL MONITORING WELL
PRE-1990 ALLUVIAL MONITORING WELL
INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI REPORT
TOTAL VOCs
ISOCONCENTRATION MAP
FOR THE ALLUVIAL/COLLUVIAL
UHSU GROUNDWATER FLOW SYSTEM
SECOND QUARTER 1992
FIGURE 4.4-4
APRIL 1995

174


P209389
P209489
P210089
1986
North East Access Rd.
North West Access Rd.
Patrol Rd.
P114389
ND
P114589
ND
P115589
P209889
P209589
ND
B208089
ND
3987
05093
P208989
P208889
B208189
ND
P218389
ND
P209789
1,1,1-Trichloroethane 6.9 3.4 12
1,1,2-Trichloroethane 0.9 0.8 1
1,1-Dichloroethane 36.8 26 58
1,1-Dichloroethene 24.8 11.6 49
1,2-Dichloroethane 0.2 0.2 0.03
Chloroform 1.1 0.79 2
Methylene Chloride 0.02 0.1 0.3
cis-1,2-Dichloroethene 0.9 0.9 0.9
Acetone 5 5 5
1,1-Dichloroethane 13 13 13
Methylene Chloride 3.3 1 8
Toluene 2 2 2
cis-1,1-Dichloroethene 0.6 0.3 1
trans-1,1-Dichloroethene 0.2 0.2 0.3
1,1,1-Trichloroethane 2.8 1 5
1,1-Dichloroethane 2 1 3
1,1-Dichloroethene 57.9 27 92
1,2-Dichloroethane 0.62 0.62 0.62
1,2-Dichloroethene 2 2 2
Acetone 13 13 13
Chloroform 7.8 4.78 13
Methylene Chloride 2.8 0.3 5.8
Napthalene 2 2 2
cis-1,2-Dichloroethene 0.8 0.76 0.94
Chloroform 100 73 140
Methylene Chloride 6 6 6
P209289
2186
ND
P114689
3086
89
P207889
ND
76292
2286
1,1,2-Trichloroethane 0.3 0.3 0.3
2-Butanone 4 4 4
Acetone 6.7 2 11
Benzene 1 1 1
Carbon Disulfide 0.9 0.9 0.9
Methylene Chloride 4.6 1 9
Xylenes 2 2 2
cis-1,3-Dichloropropene 1 1 1
P207989
ND
P209689
ND
P219489
P114489
ND
P114989
ND
1,1,1-Trichloroethane 2.8 1.1 4
1,1-Dichloroethane 1.6 0.9 3
1,1-Dichloroethene 4.1 2.1 7
1,2,3-Trichlorobenzene 0.6 0.6 0.6
1,2-Trichloropropane 0.5 0.5 0.5
Bis(2-Ethylhexyl)phthalate 130 130 130
Chloroform 0.7 0.5 1
Di-n-Octyl Phthalate 6 6 6
Diethyl Phthalate 3 3 3
Methylene Chloride 1.1 1.1 1.1
Vinyl Chloride 0.7 0.7 0.7
cis-1,1-Dichloroethene 4.3 3 5.9
2386
ND
2586
2686
Acetone 46 46 46
Methylene Chloride 4.3 3 6
P207789
P115089
ND
1,1,1-Trichloroethane 95.5 77 150
1,1,2-Trichloroethane 1.1 1 1.3
1,1-Dichloroethene 49.5 35 58
1,1,3-Trichlorobenzene 16.8 6 23
1,1,4-Trichlorobenzene 47.3 17 80
1,2-Dichlorobenzene 0.6 0.6 0.6
1,2-Dichloroethane 8.3 6 11
Chloroform 6.3 3.7 10
Ethylbenzene 0.7 0.7 0.7
Naphthalene 0.68 0.68 0.68
Trichlorofluoromethane 1.7 1.7 1.7
Vinyl Chloride 2.5 2 3
cis-1,1-Dichloroethene 25.7 20 34
Acetone 10.3 5 17
Benzene 4 4 4
Carbon Disulfide 0.2 0.2 0.2
Chloroform 2 2 2
Methylene Chloride 4.8 3 6
Toluene 15 15 15
Xylenes 8 8 8
Vinyl Acetate 2 2 2
P219589
5687
P207589
ND
P114889
P114789
Sage Rd.
P207389
ND
Tenth St.
1,1,1-Trichloroethane 135 88 200
1,1,2-Trichloroethane 6.2 5.3 7
1,1-Dichloroethane 460.2 160 750
1,1-Dichloroethene 594 60 1000
1,2,3-Trichlorobenzene 1.5 0.98 2
1,2,4-Trichlorobenzene 2 2 2
1,2-Dichloroethane 46.8 39.1 54
1,2-Dichloropropane 2.6 2.2 3
Chloroethane 1.3 0.52 2
Chloroform 2.5 2 3
Diethyl Phthalate 2 2 2
Methylene Chloride 3.3 1.5 5
Trichlorofluoromethane 2.8 2.8 2.8
Vinyl Chloride 18 10 26
cis-1,1-Dichloroethene 190.7 40 300
trans-1,1-Dichloroethene 1.6 1.1 2
P115689
1,1,1-Trichloroethane 53.8 27.6 72
1,1,2-Trichloroethane 0.6 0.52 0.8
1,1-Dichloroethane 3.5 1.99 4.7
1,1-Dichloroethene 80.4 51.9 98
1,2,3-Trichlorobenzene 15 15 15
1,2-Dichloroethane 0.9 0.82 1.1
Bis(2-Ethylhexyl)phthalate 14.3 13 15
Di-n-Octyl Phthalate 2 2 2
cis-1,1-Dichloroethene 88.1 37.5 210
Patrol Rd.
1,1,1-Trichloroethane 9.6 7 12
1,1,2-Trichloroethane 1 1 1
1,1-Dichloroethane 1 1 1
1,1-Dichloroethene 94 27 140
1,2-Dichloroethene 0.8 0.8 0.8
Bis(2-Ethylhexyl)phthalate 17 17 17
Vinyl Chloride 53.5 16 78
cis-1,1-Dichloroethene 178.3 80 230
trans-1,1-Dichloroethene 0.6 0.6 0.6
P415889
ND
P215789
Central Ave.
P415989
ND
313489
P416889
Chloroform 0.2 0.1 0.3
Methylene Chloride 0.6 0.6 0.6
P416989
ND
P416289
P218289
Seventh Ave.
37791
ND
37591
P416089
ND
P416189
ND
22293
ND
P416489
ND
P416589
5287
ND
37891
Cactus Rd.
37991
LEGEND
Analyte Mean ppb Min ppb Max ppb
Chloroform 0.2 0.1 0.3
Methylene Chloride 0.6 0.6 0.6
P416389
181
P416689
P416789
P416889
P314289
ND
5187
P313589
NOTE: Not all compounds were analyzed for all wells.

IHSS 118.1
IA PLUME
POTENTIOMETRIC SURFACE MAP*



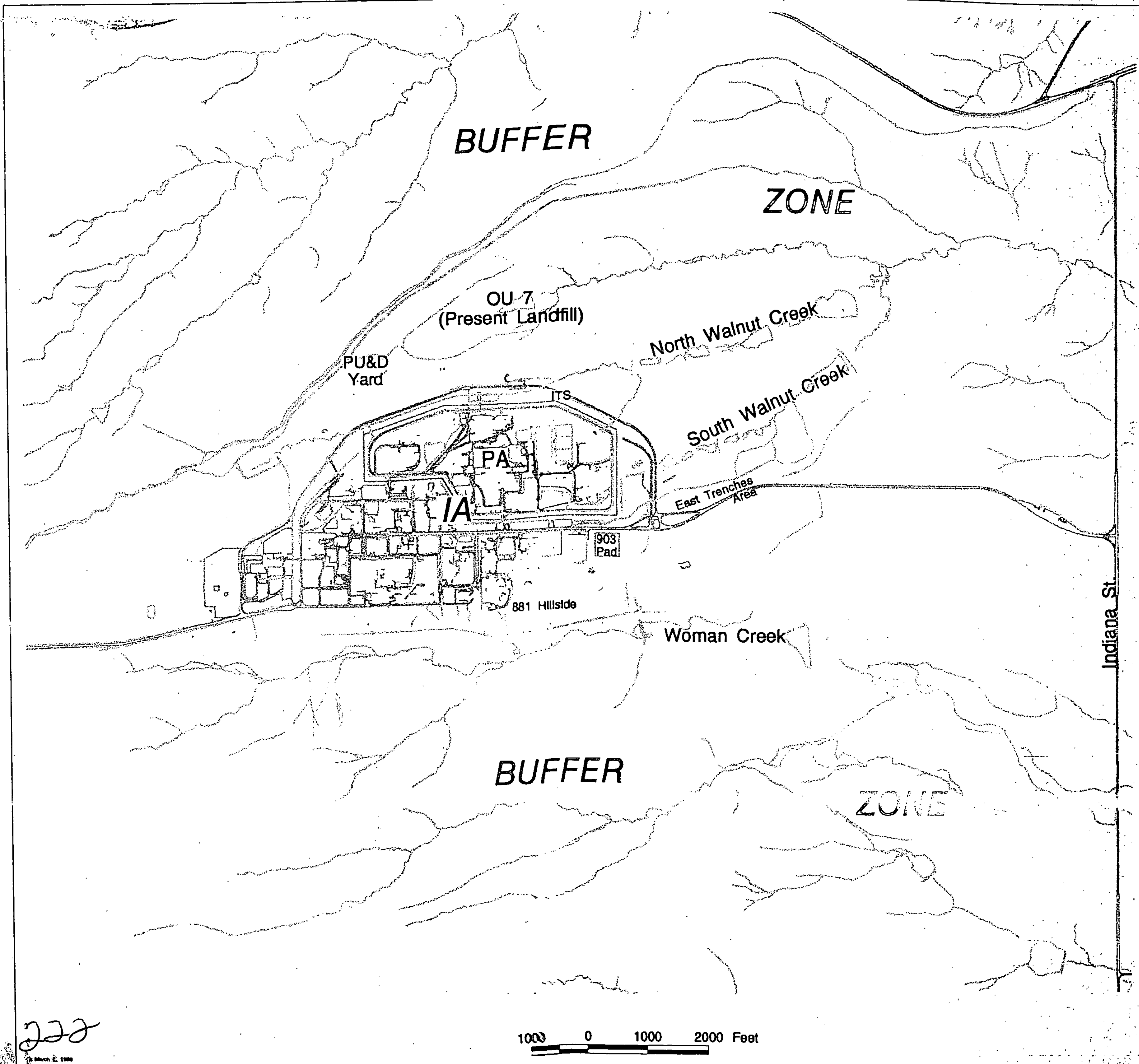
= GROUNDWATER FLOW DIRECTION (40' CONTOUR INT.)

= GROUND WATER CONTAMINANT PLUME (100x MCL)

* CONTOURS REFLECT LOCAL INFLUENCE OF BLDG. FOUNDATION / FOOTING DRAINS.

1" = 200 ft.

182



Location Reference Map

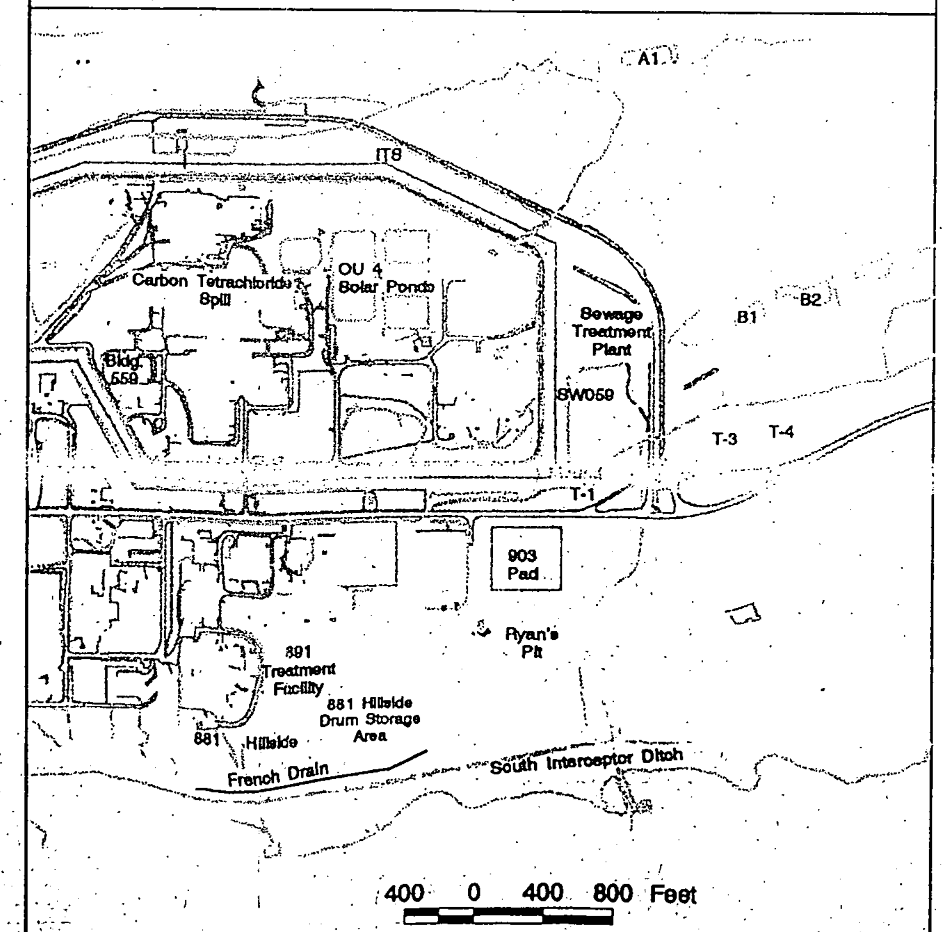
Location of areas of interest refered to in text.

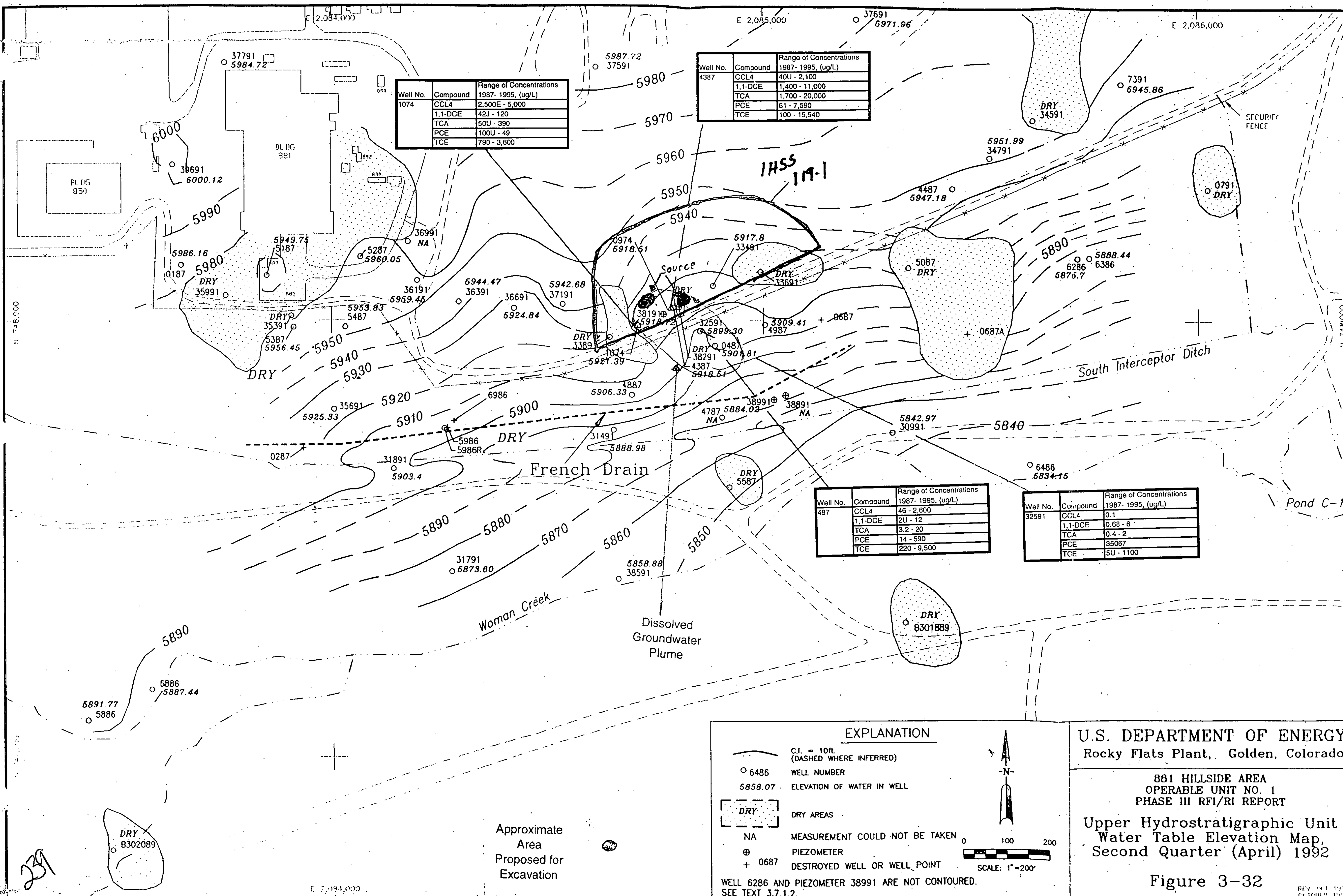
Figure 1-1

N

Nice addition

Detailed View of East Side of Plant Site





Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
1074	CCL4	2,500E - 5,000
	1,1-DCE	42J - 120
	TCA	50U - 390
	PCE	100U - 49
	TCE	790 - 3,600

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
4387	CCL4	40U - 2,100
	1,1-DCE	1,400 - 11,000
	TCA	1,700 - 20,000
	PCE	61 - 7,590
	TCE	100 - 15,540

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
487	CCL4	46 - 2,600
	1,1-DCE	2U - 12
	TCA	3.2 - 20
	PCE	14 - 590
	TCE	220 - 9,500

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
32591	CCL4	0.1
	1,1-DCE	0.68 - 6
	TCA	0.4 - 2
	PCE	35067
	TCE	5U - 1100

EXPLANATION

C.I. = 10ft. (DASHED WHERE INFERRED)
6486 WELL NUMBER
5858.07 ELEVATION OF WATER IN WELL
DRY — DRY AREAS
NA — MEASUREMENT COULD NOT BE TAKEN
⊕ PIEZOMETER
+ 0687 DESTROYED WELL OR WELL POINT

-N-
0 100 200
SCALE: 1" = 200'

WELL 6286 AND PIEZOMETER 38991 ARE NOT CONTOURED.
SEE TEXT 3.7.1.2.

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant, Golden, Colorado

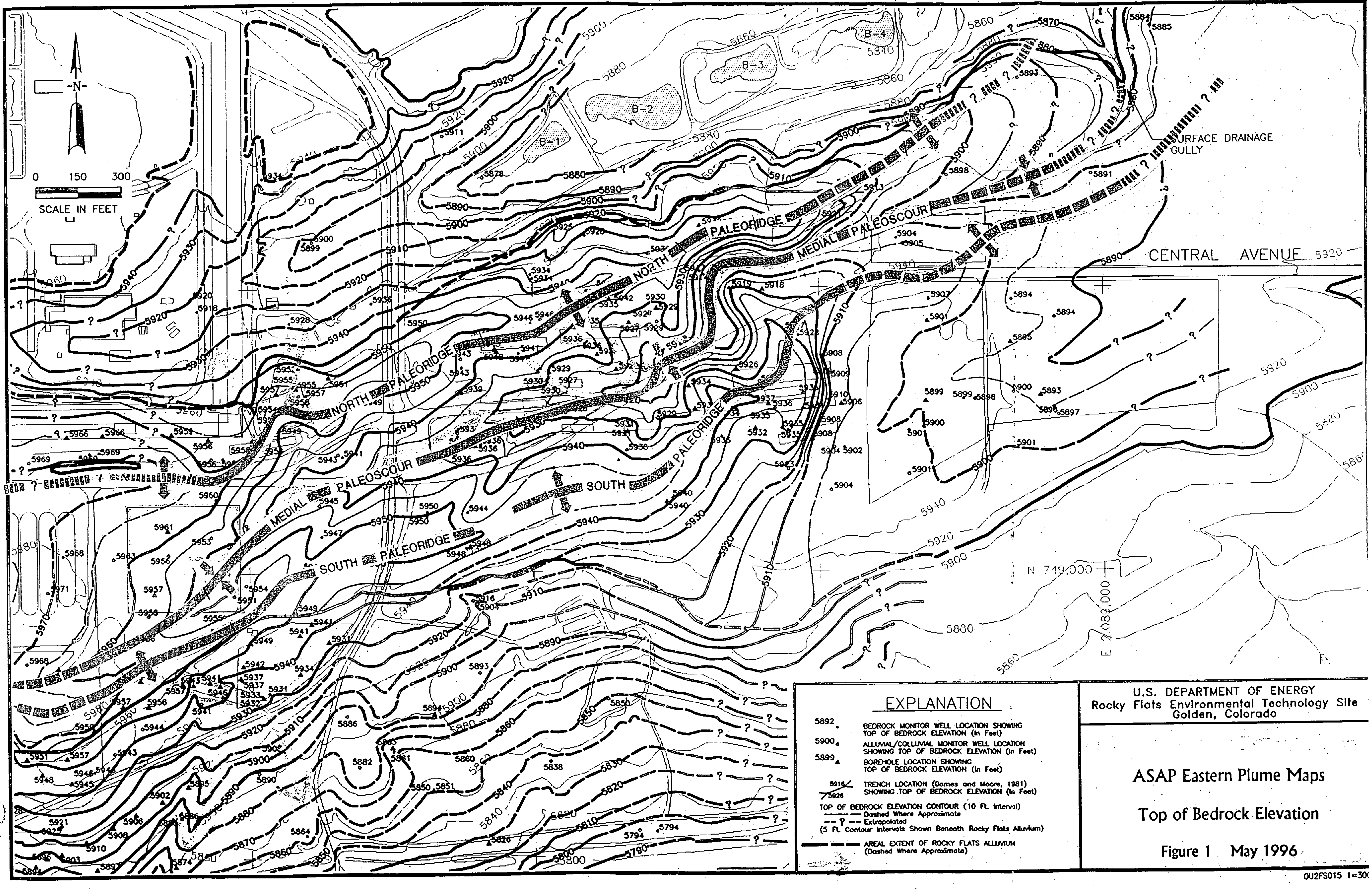
881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Upper Hydrostratigraphic Unit Water Table Elevation Map, Second Quarter (April) 1992

Figure 3-32

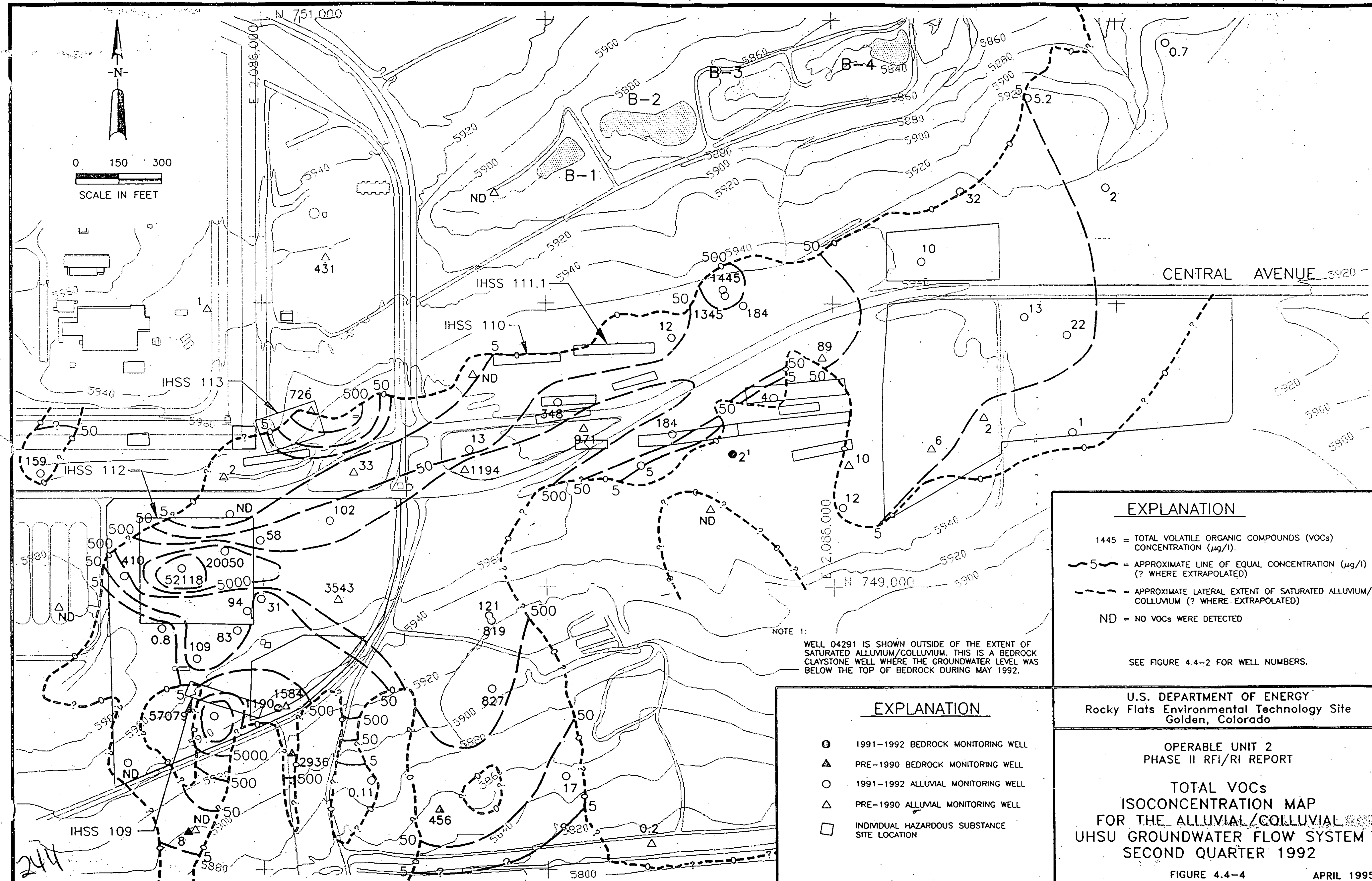
REV. OCT. 1992
OCTOBER 1992

239

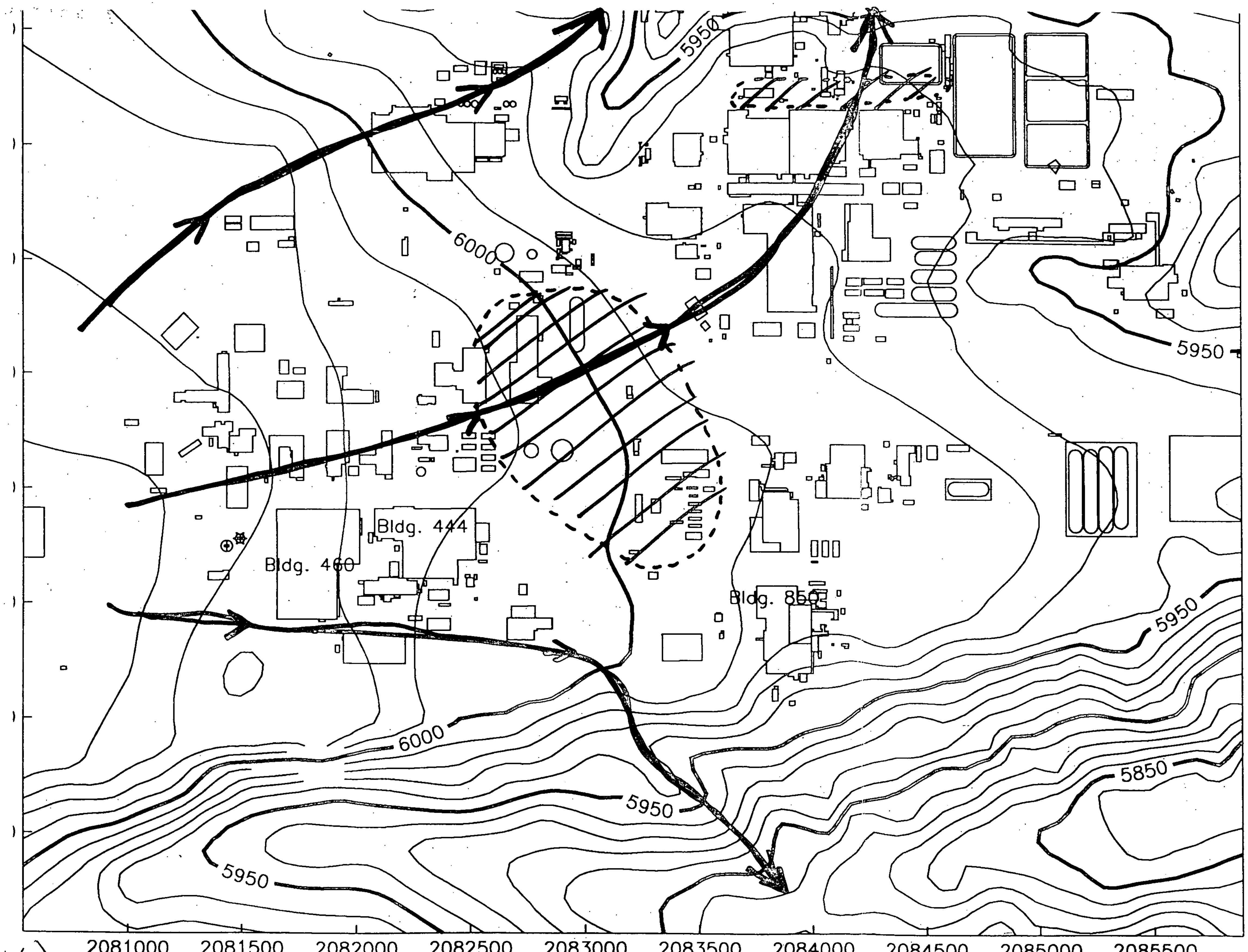


-N-
0 150 300
SCALE IN FEET
NORTH PALEORIDGE
MEDIAL PALEOSCOUR
SOUTH PALEORIDGE
CENTRAL AVENUE
SURFACE DRAINAGE GULLY
B-1
B-2
B-3
B-4
N 749,000
E 2,089,000
EXPLANATION
5892 • BEDROCK MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (In Feet)
5900 o ALLUVIAL/COLLUVIAL MONITOR WELL LOCATION SHOWING TOP OF BEDROCK ELEVATION (In Feet)
5899 ▲ BOREHOLE LOCATION SHOWING TOP OF BEDROCK ELEVATION (In Feet)
5916 / 5926 TRENCH LOCATION (Dames and Moore, 1981) SHOWING TOP OF BEDROCK ELEVATION (In Feet)
TOP OF BEDROCK ELEVATION CONTOUR (10 Ft. Interval)
Dashed Where Approximate
? Extrapolated
(5 Ft. Contour Intervals Shown Beneath Rocky Flats Alluvium)
AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximate)
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado
ASAP Eastern Plume Maps
Top of Bedrock Elevation
Figure 1 May 1996
OU2FS015 1=300

242



N
0 150 300
SCALE IN FEET
N 751,000
E 2,086,000
B-1
B-2
B-3
B-4
CENTRAL AVENUE
IHSS 111.1
IHSS 110
IHSS 113
IHSS 112
IHSS 109
N 749,000
E 2,088,000
NOTE 1:
WELL 04291 IS SHOWN OUTSIDE OF THE EXTENT OF SATURATED ALLUVIUM/COLLUVIUM. THIS IS A BEDROCK CLAYSTONE WELL WHERE THE GROUNDWATER LEVEL WAS BELOW THE TOP OF BEDROCK DURING MAY 1992.
EXPLANATION
1445 = TOTAL VOLATILE ORGANIC COMPOUNDS (VOCs) CONCENTRATION (µg/l).
5 = APPROXIMATE LINE OF EQUAL CONCENTRATION (µg/l) (? WHERE EXTRAPOLATED)
= APPROXIMATE LATERAL EXTENT OF SATURATED ALLUVIUM/COLLUVIUM (? WHERE EXTRAPOLATED)
ND = NO VOCs WERE DETECTED
SEE FIGURE 4.4-2 FOR WELL NUMBERS.
EXPLANATION
1991-1992 BEDROCK MONITORING WELL
PRE-1990 BEDROCK MONITORING WELL
1991-1992 ALLUVIAL MONITORING WELL
PRE-1990 ALLUVIAL MONITORING WELL
INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI REPORT
TOTAL VOCs
ISOCONCENTRATION MAP
FOR THE ALLUVIAL/COLLUVIAL
UHSU GROUNDWATER FLOW SYSTEM
SECOND QUARTER 1992
FIGURE 4.4-4
APRIL 1995
244



IHSS 118.1
IA PLUME
POTENTIOMETRIC
SURFACE MAP*

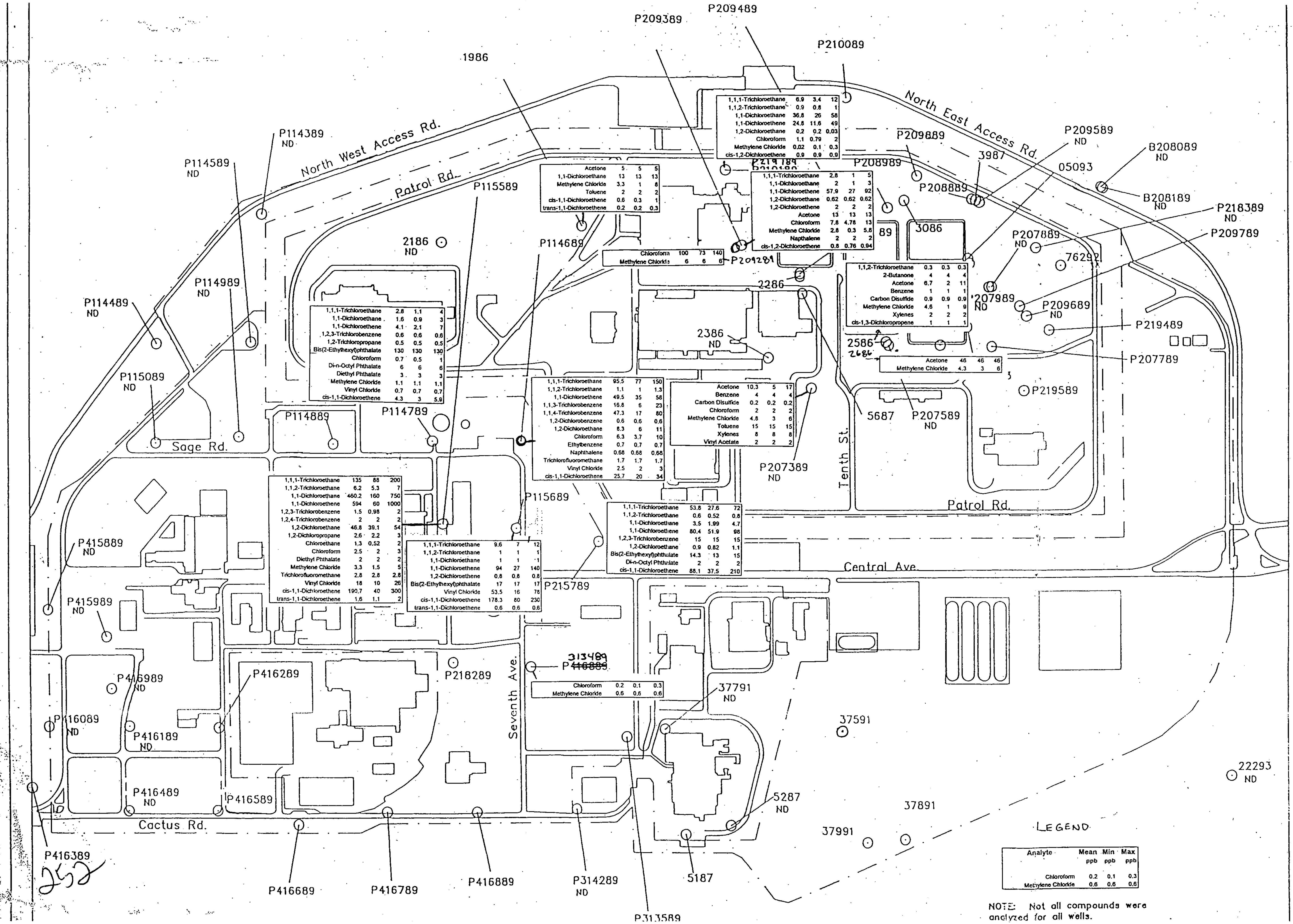
= GROUNDWATER FLOW DIRECTION (40' CONTOUR INT.)

= GROUND WATER CONTAMINANT PLUME (100x MCL)

* CONTOURS REFLECT LOCAL INFLUENCE OF BLDG. FOUNDATION / FOOTING DRAINS.

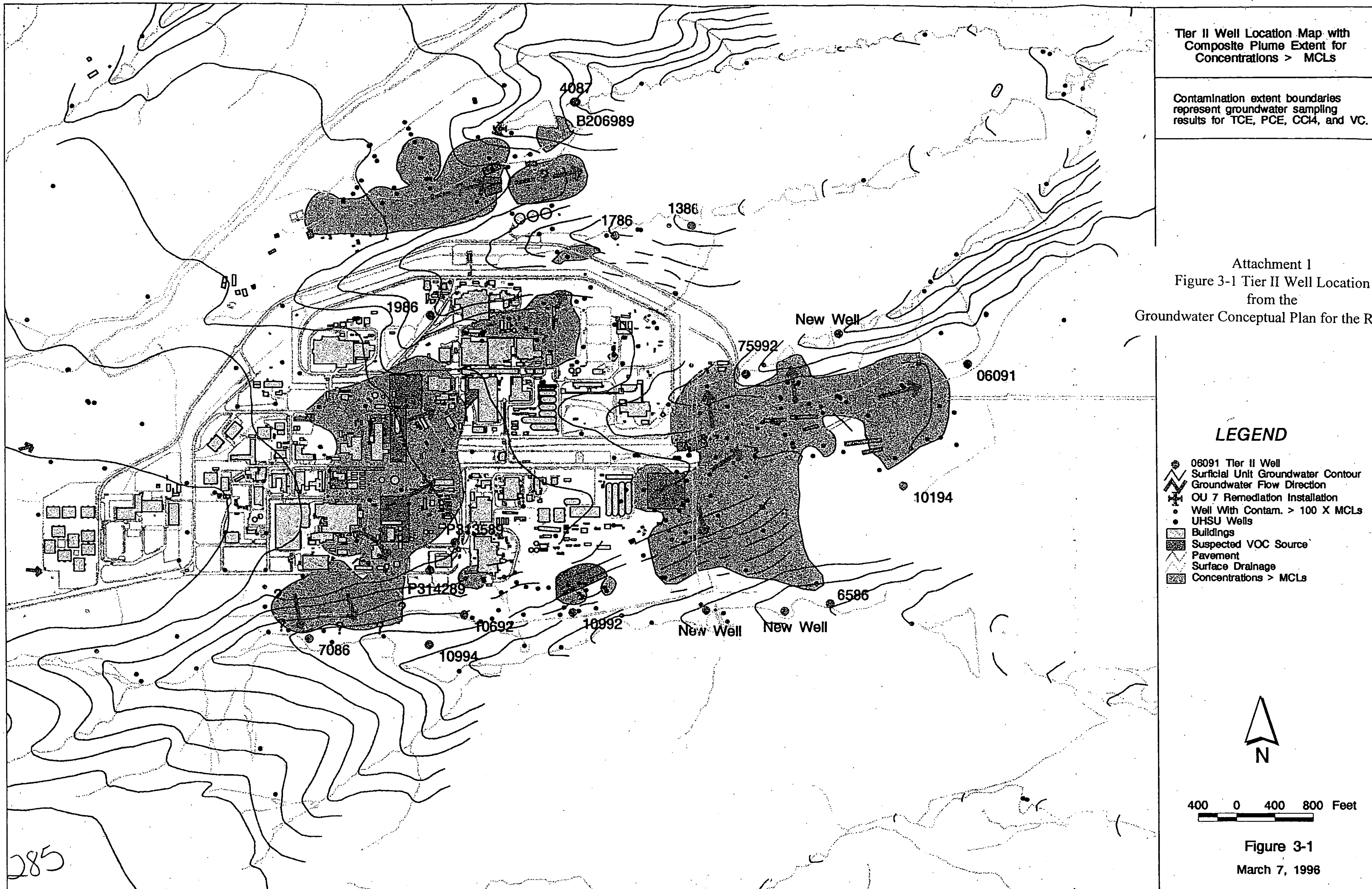
1" = 200 ft.

251



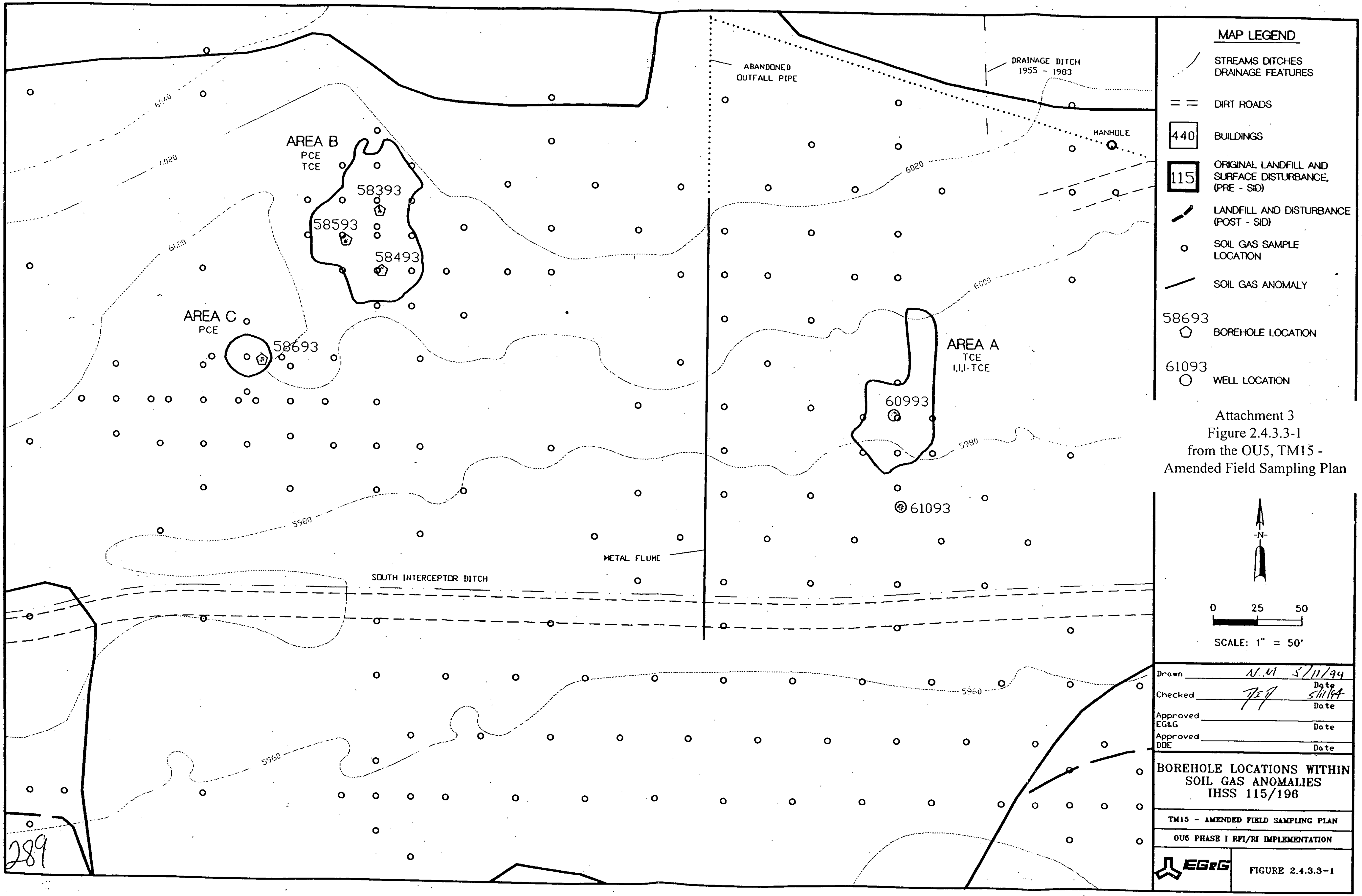
North West Access Rd.
Patrol Rd.
North East Access Rd.
Sage Rd.
Central Ave.
Cactus Rd.
Seventh Ave.
Tenth St.
Patrol Rd.
P209389
P209489
P210089
1986
P114389
ND
P114589
ND
P115589
P209889
P209589
ND
B208089
ND
3987
05093
P208989
P208889
B208189
ND
P218389
ND
P209789
2186
ND
P114689
3086
P207889
ND
76292
P219189
P209289
2286
P114489
ND
P114989
ND
207989
ND
P209689
ND
P219489
2386
ND
2586
2686
P207789
P115089
ND
P219589
P114889
P114789
5687
P207589
ND
P207389
ND
P115689
P415889
ND
P215789
P415989
ND
313489
P416889
P218289
P416989
ND
P416289
37791
ND
P416089
ND
P416189
ND
37591
22293
ND
P416489
ND
P416589
5287
ND
37891
37991
P416389
P416689
P416789
P416889
P314289
ND
5187
P313589
1,1,1-Trichloroethane 6.9 3.4 12
1,1,2-Trichloroethane 0.9 0.8 1
1,1-Dichloroethane 36.8 26 58
1,1-Dichloroethene 24.8 11.6 49
1,2-Dichloroethane 0.2 0.2 0.03
Chloroform 1.1 0.79 2
Methylene Chloride 0.02 0.1 0.3
cis-1,2-Dichloroethene 0.9 0.9 0.9
Acetone 5 5 5
1,1-Dichloroethane 13 13 13
Methylene Chloride 3.3 1 8
Toluene 2 2 2
cis-1,1-Dichloroethene 0.6 0.3 1
trans-1,1-Dichloroethene 0.2 0.2 0.3
1,1,1-Trichloroethane 2.8 1 5
1,1-Dichloroethane 2 1 3
1,1-Dichloroethene 57.9 27 92
1,2-Dichloroethane 0.62 0.62 0.62
1,2-Dichloroethene 2 2 2
Acetone 13 13 13
Chloroform 7.8 4.78 13
Methylene Chloride 2.8 0.3 5.8
Napthalene 2 2 2
cis-1,2-Dichloroethene 0.8 0.76 0.94
Chloroform 100 73 140
Methylene Chlorkls 6 6 6
1,1,2-Trichloroethane 0.3 0.3 0.3
2-Butanone 4 4 4
Acetone 6.7 2 11
Benzene 1 1 1
Carbon Disulfide 0.9 0.9 0.9
Methylene Chloride 4.6 1 9
Xylenes 2 2 2
cis-1,3-Dichloropropene 1 1 1
1,1,1-Trichloroethane 2.8 1.1 4
1,1-Dichloroethane 1.6 0.9 3
1,1-Dichloroethene 4.1 2.1 7
1,2,3-Trichlorobenzene 0.6 0.6 0.6
1,2-Trichloropropane 0.5 0.5 0.5
Bis(2-Ethylhexyl)phthalate 130 130 130
Chloroform 0.7 0.5 1
Di-n-Octyl Phthalate 6 6 6
Diethyl Phthalate 3 3 3
Methylene Chloride 1.1 1.1 1.1
Vinyl Chloride 0.7 0.7 0.7
cis-1,1-Dichloroethene 4.3 3 5.9
Acetone 46 46 46
Methylene Chloride 4.3 3 6
1,1,1-Trichloroethane 95.5 77 150
1,1,2-Trichloroethane 1.1 1 1.3
1,1-Dichloroethene 49.5 35 58
1,1,3-Trichlorobenzene 16.8 6 23
1,1,4-Trichlorobenzene 47.3 17 80
1,2-Dichlorobenzene 0.6 0.6 0.6
1,2-Dichloroethane 8.3 6 11
Chloroform 6.3 3.7 10
Ethylbenzene 0.7 0.7 0.7
Naphthalene 0.68 0.68 0.68
Trichlorofluoromethane 1.7 1.7 1.7
Vinyl Chloride 2.5 2 3
cis-1,1-Dichloroethene 25.7 20 34
Acetone 10.3 5 17
Benzene 4 4 4
Carbon Disulfide 0.2 0.2 0.2
Chloroform 2 2 2
Methylene Chloride 4.8 3 6
Toluene 15 15 15
Xylenes 8 8 8
Vinyl Acetate 2 2 2
1,1,1-Trichloroethane 135 88 200
1,1,2-Trichloroethane 6.2 5.3 7
1,1-Dichloroethane 460.2 160 750
1,1-Dichloroethene 594 60 1000
1,2,3-Trichlorobenzene 1.5 0.98 2
1,2,4-Trichlorobenzene 2 2 2
1,2-Dichloroethane 46.8 39.1 54
1,2-Dichloropropane 2.6 2.2 3
Chloroethane 1.3 0.52 2
Chloroform 2.5 2 3
Diethyl Phthalate 2 2 2
Methylene Chloride 3.3 1.5 5
Trichlorofluoromethane 2.8 2.8 2.8
Vinyl Chloride 18 10 26
cis-1,1-Dichloroethene 190.7 40 300
trans-1,1-Dichloroethene 1.6 1.1 2
1,1,1-Trichloroethane 9.6 7 12
1,1,2-Trichloroethane 1 1 1
1,1-Dichloroethane 1 1 1
1,1-Dichloroethene 94 27 140
1,2-Dichloroethene 0.8 0.8 0.8
Bis(2-Ethylhexyl)phthalate 17 17 17
Vinyl Chloride 53.5 16 78
cis-1,1-Dichloroethene 178.3 80 230
trans-1,1-Dichloroethene 0.6 0.6 0.6
1,1,1-Trichloroethane 53.8 27.6 72
1,1,2-Trichloroethane 0.6 0.52 0.8
1,1-Dichloroethane 3.5 1.99 4.7
1,1-Dichloroethene 80.4 51.9 98
1,2,3-Trichlorobenzene 15 15 15
1,2-Dichloroethane 0.9 0.82 1.1
Bis(2-Ethylhexyl)phthalate 14.3 13 15
Di-n-Octyl Phthalate 2 2 2
cis-1,1-Dichloroethene 88.1 37.5 210
Chloroform 0.2 0.1 0.3
Methylene Chloride 0.6 0.6 0.6
LEGEND
Analyte Mean ppb Min ppb Max ppb
Chloroform 0.2 0.1 0.3
Methylene Chloride 0.6 0.6 0.6
NOTE: Not all compounds were analyzed for all wells.

252

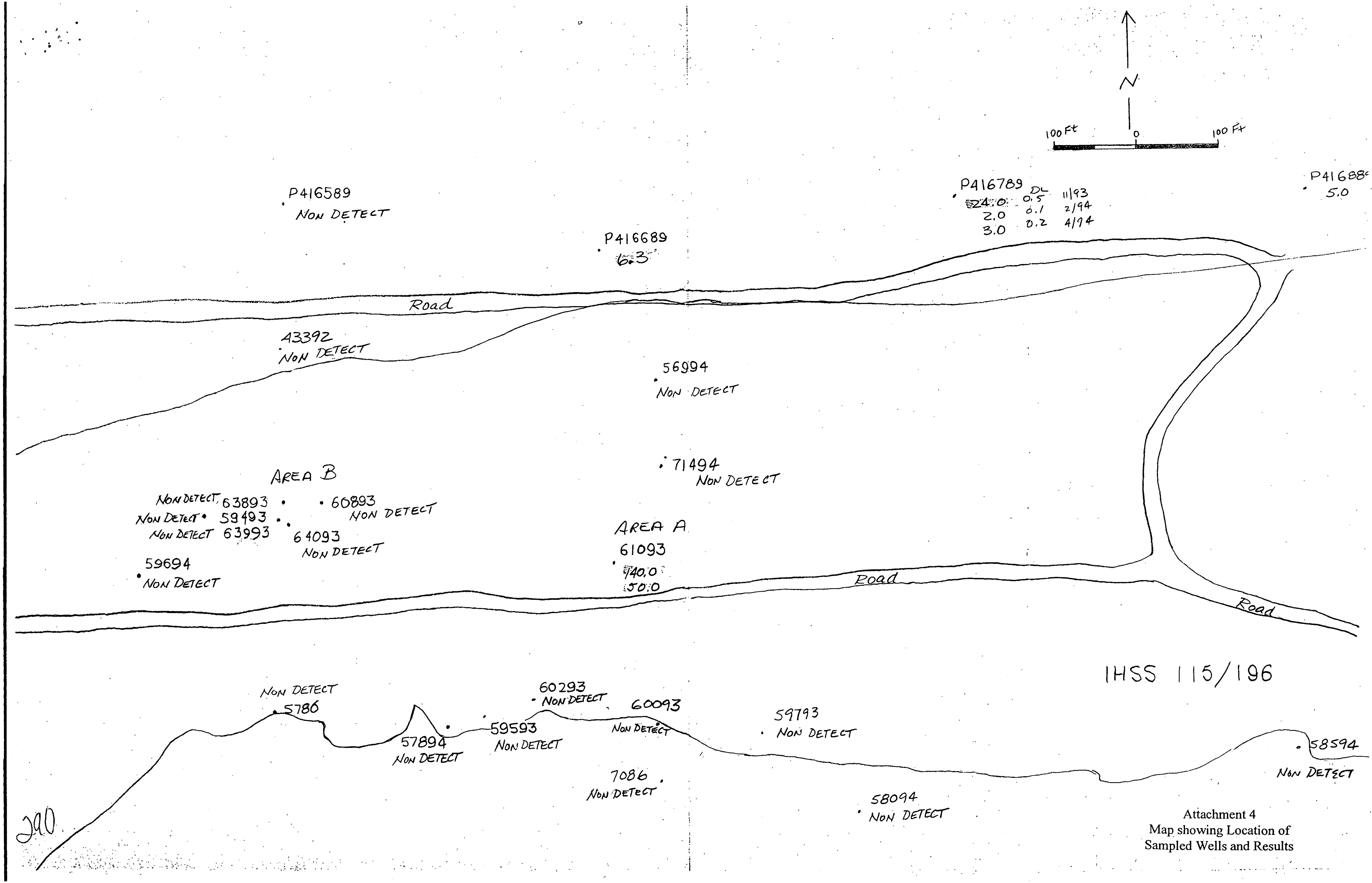


Attachment 1
Figure 3-1 Tier II Well Location
from the
Groundwater Conceptual Plan for the RFETS

285



Attachment 3
Figure 2.4.3.3-1
from the OU5, TM15 -
Amended Field Sampling Plan



Attachment 4
Map showing Location of
Sampled Wells and Results

Rock Creek ? Cabel

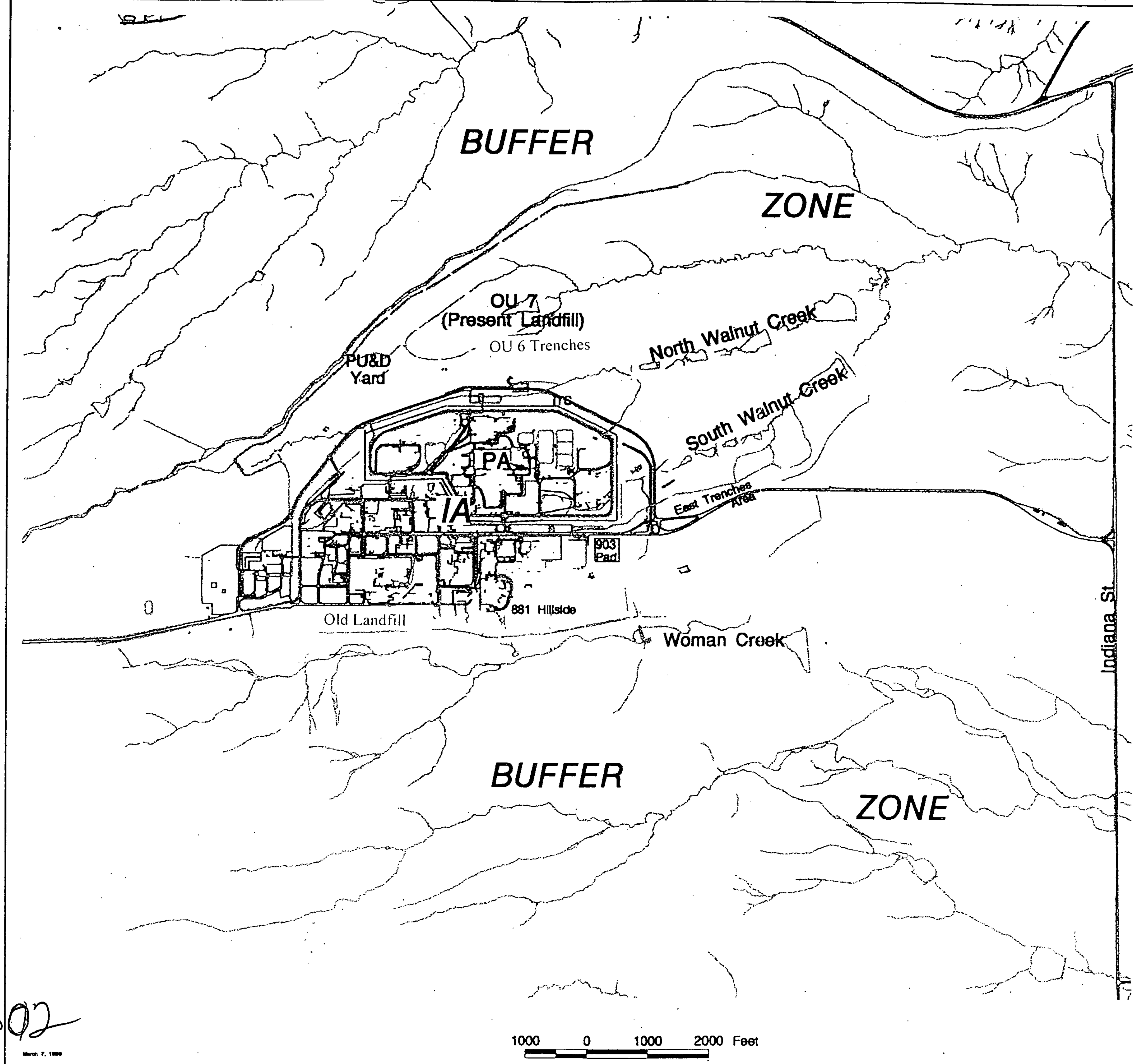
Location Reference Map

Location of areas of interest refered to in text.

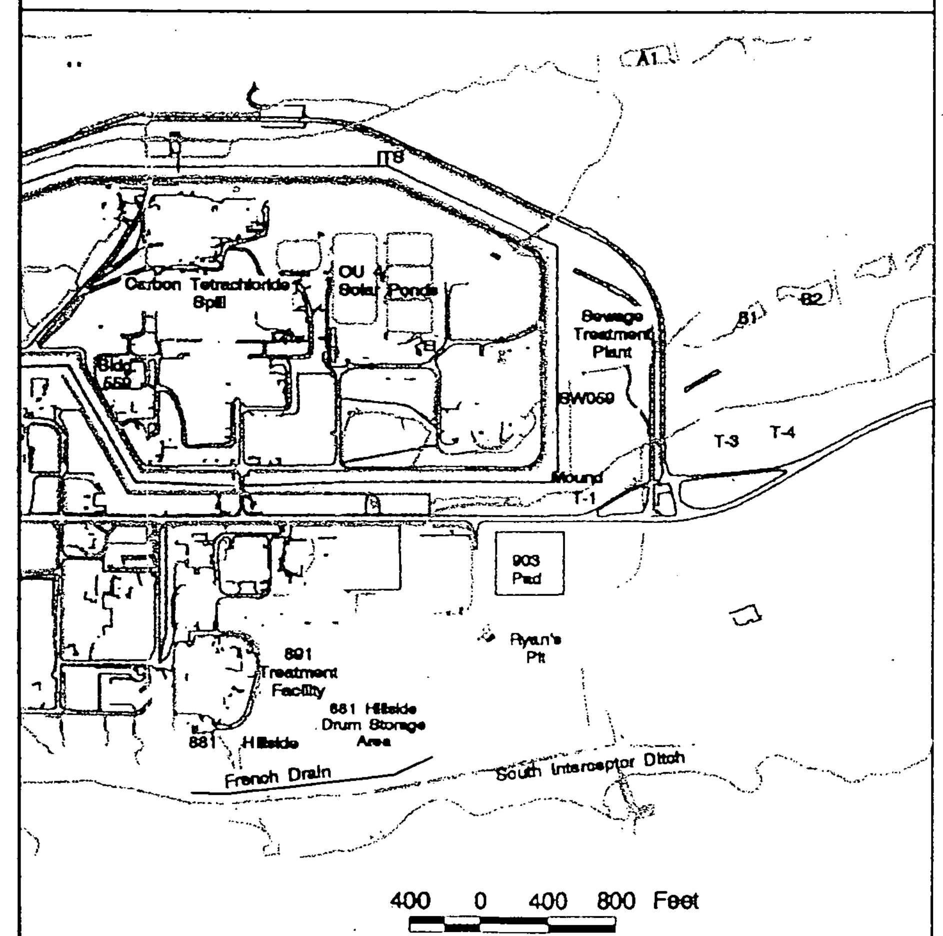
Figure 1-1

Ryan's Pit?

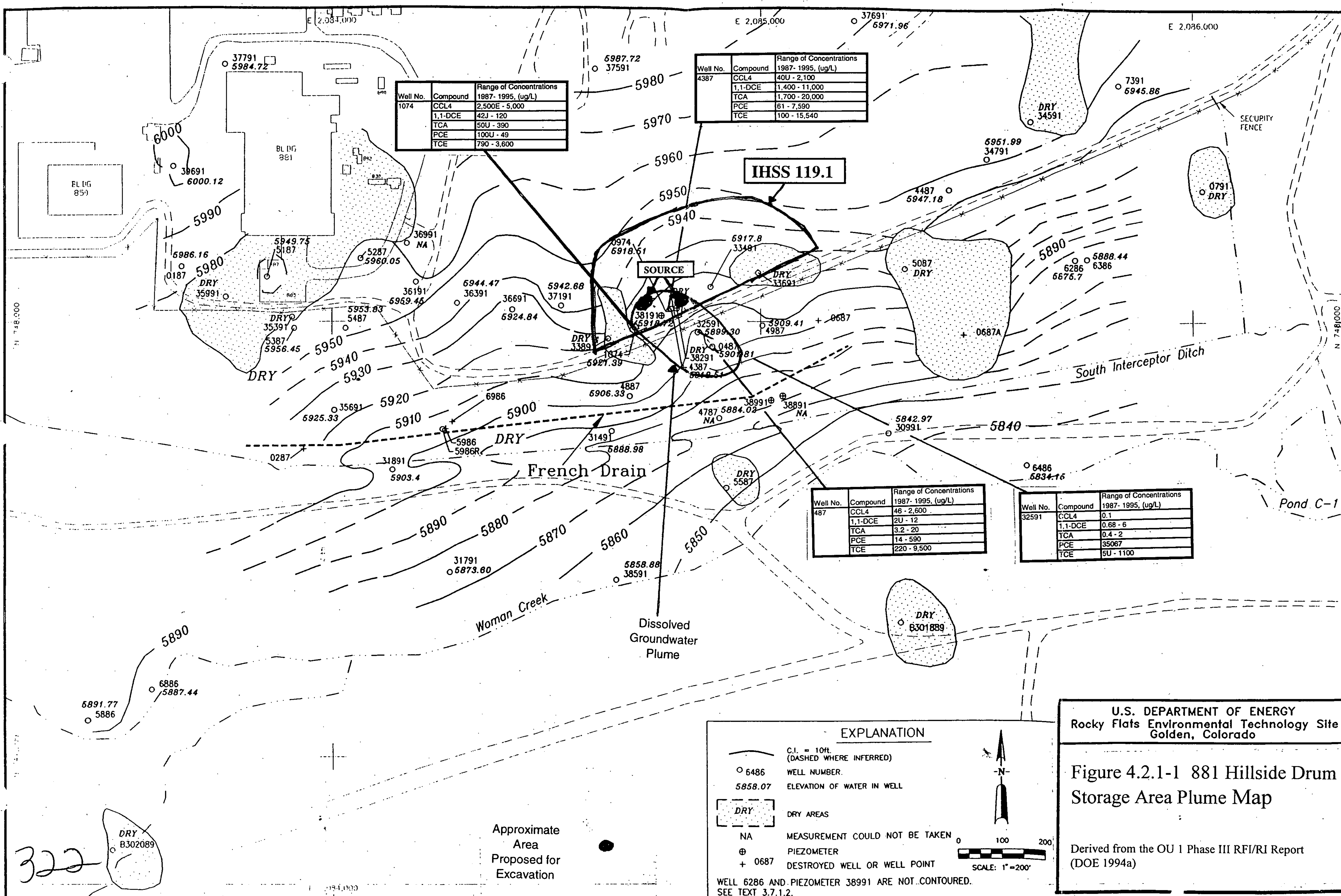
N



Detailed View of East Side of Plant Site



302



Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
1074	CCL4	2,500E - 5,000
	1,1-DCE	42J - 120
	TCA	50U - 390
	PCE	100U - 49
	TCE	790 - 3,600

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
4387	CCL4	40U - 2,100
	1,1-DCE	1,400 - 11,000
	TCA	1,700 - 20,000
	PCE	61 - 7,590
	TCE	100 - 15,540

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
487	CCL4	46 - 2,600
	1,1-DCE	2U - 12
	TCA	3.2 - 20
	PCE	14 - 590
	TCE	220 - 9,500

Well No.	Compound	Range of Concentrations 1987- 1995, (ug/L)
32591	CCL4	0.1
	1,1-DCE	0.68 - 6
	TCA	0.4 - 2
	PCE	35067
	TCE	5U - 1100

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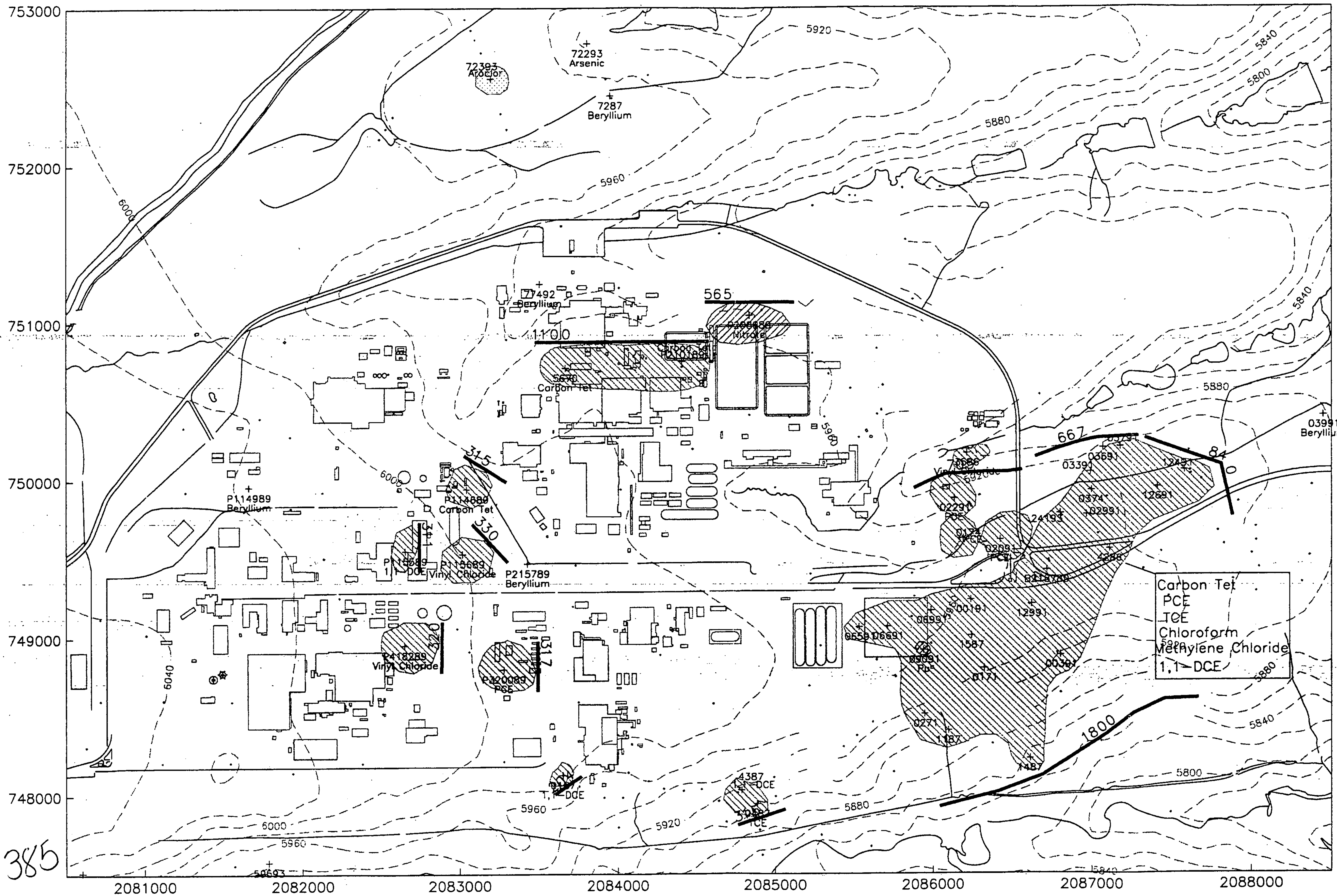
Golden, Colorado

Figure 4.2.1-1 881 Hillside Drum Storage Area Plume Map

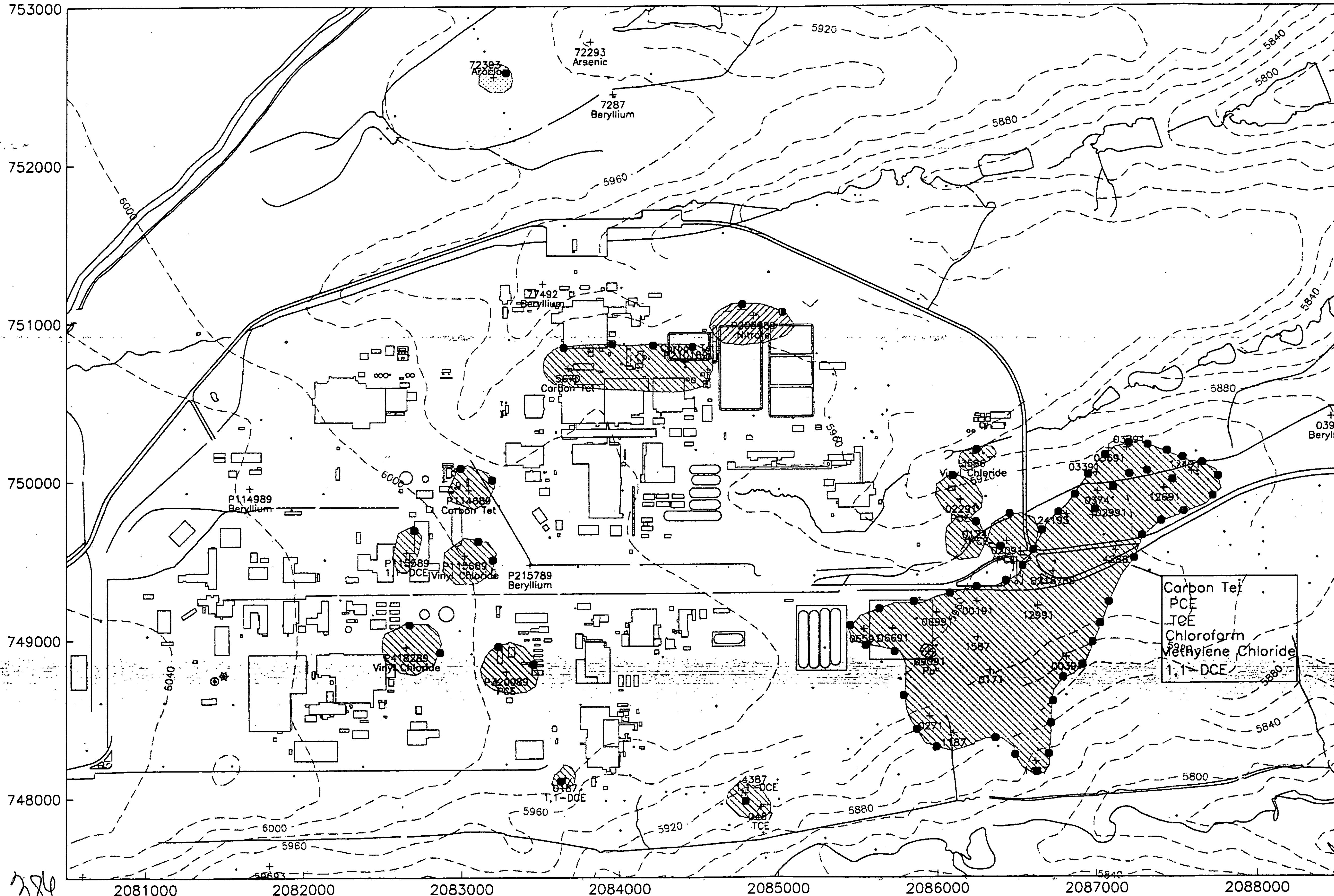
Derived from the OU 1 Phase III RFI/RI Report (DOE 1994a)

Generalized Trench Locations For Groundwater Capture (DRAFT)



385

Proposed Extraction Wells For Groundwater Capture (DRAFT)



384

Generalized Plume Boundaries For Groundwater Sites Above PPRGs (DRAFT)